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Antennas for TV, CB, FM, Shortwave

HOW TO SELECT AND
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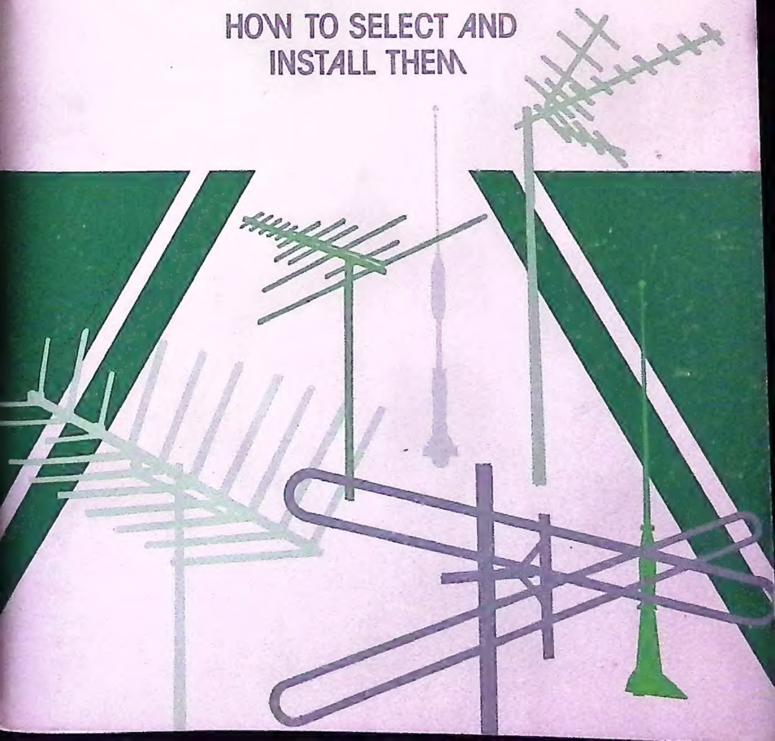

ANTENNAS FOR TV, CB, FM, SHORTWAVE—
How To Select And Install Them

by
Franklin E. Swan

A Revision of

ANTENNAS FOR TV, CB, SHORTWAVE

by Louis M. Dezettel

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PREFACE

Modern electronics has resulted in a considerable improvement in the performance of color TV sets, Citizens band equipment and other equipment using antennas to receive a signal. One thing even sophisticated circuitry can't seem to affect is the action of the radio waves coming to the set. Whatever control we have external to the set takes the form of an antenna.

This book is a revision of *Antennas for TV, CB, Shortwave* which was a revision of *Introduction to Antennas* by Louis M. Dezettel. This need for constant up-dating is a reflection of both the improvement in equipment and changes in laws controlling the manufacture and installation of antenna systems. This latest revision includes the laws going into affect by mid 1983.

With the considerable dollar investment in a good color TV set, CB transceiver, shortwave radio, or FM hi-fi equipment, it becomes important to give thought to the selection of the antenna and, just as important, its installation. You can enhance the performance of your investment by spending a few minutes reading this book and following its suggestion. It can make the difference between passable performance and very good performance.

Along with many others I would like to thank Mr. Dezettel for his many years of technical writing, and wish him well in his retirement.

FRANKLIN E. SWAN

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CHAPTER 1

WHAT ANTENNAS DO

Thousands of watts of radio-wave power, transmitted from a TV or other transmitting antenna, are radiated outward. By the time they get to your receiving antenna very little is left. The amount of power your TV antenna actually feeds to your set may be on the order of two or three hundred microwatts (millionths of a watt). It is for this reason that it is important to use a highly efficient antenna, especially if there is any appreciable distance between the transmitter and the receiver.

For the mathematically minded, the loss of power is the same as for light—the inverse-square law applies. That is, the loss is in *inverse* proportion to the *square* of the distance (Figure 1-1). The light passing through a 1-sq ft window at a distance of one foot would cover a 4-sq ft area at two feet. The intensity of the light at a single point at a distance of two feet is one-fourth that at one foot. This is the inverse-square law, and it applies as well to the decrease in power of a radio wave as it travels away from a transmitter.

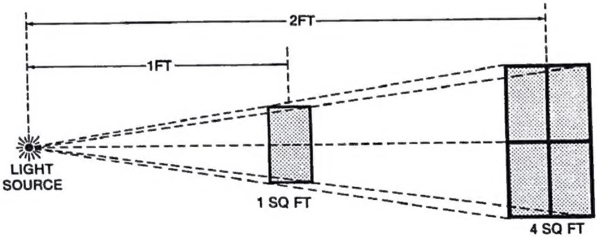


Figure 1-1. The inverse-square law.

A WORD ABOUT RESONANCE

Piano strings are different in length, and when struck by the hammer will vibrate at specific musical frequencies. The longer strings (or wires) vibrate at low frequencies and the shorter ones at higher frequencies. The length and tautness of the piano strings determine their resonant frequency, or frequency of natural vibration. This is mechanical resonance.

Transmitters and receivers contain resonant circuits within them. When you switch channels in a TV set, you are switching to different resonant circuits. This not only makes the set selective to only the one channel, but increases the sensitivity to that channel. The resonant circuits are in the form of small coils and capacitors, and are called "lumped" resonant circuits.

When a length of wire is cut to a specific size, it becomes electrically resonant to radio waves of a specific frequency (Figure 1-2). When an antenna is resonant, it will do a much better job of converting the feeble radio waves to power that can be used by the receiver. The transmitting antenna is always built to resonate at the transmitting frequency; so are receiving antennas for communication purposes, such as CB antennas. The longer the main element of the antenna, the lower the resonant frequency, as in the case of the piano strings.

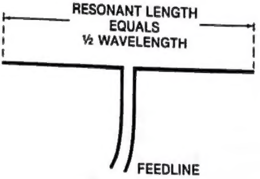


Figure 1-2. Schematic of half-wave dipole.

A current example of a resonant antenna is the Archer FM antenna in Figure 1-3. It uses two resonant dipoles on one mast, perpendicular to each other, for omnidirectional characteristics. Other examples are the CB antennas described in a later chapter.

BROADBAND ANTENNAS

To overcome the need for multiple antennas for TV reception, a single antenna with multiple elements is used to cover all the channels. Modern engineering has combined this need for multiple elements into configurations which increase gain and directivity over the use of a simple resonant antenna. Figure 1-4 shows a typical TV antenna.

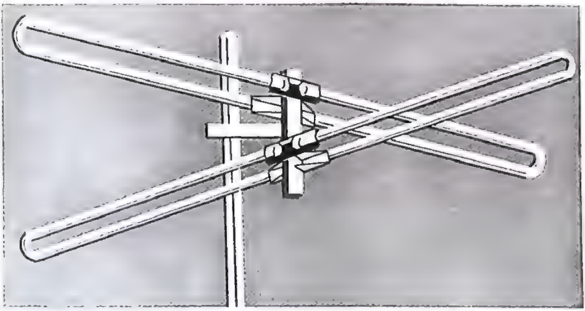


Figure 1-3. Omnidirectional FM antenna.

Each shorter element helps to direct the signal into the adjacent longer elements. Each longer element helps to reflect signals toward the adjacent shorter elements. These actions combine to provide an increase of signal strength in the direction of the shorter elements and a decrease of signal in the direction of the longer elements. The result is a very directional antenna with gain in signal strength. The added gain helps to receive weak signals, and the directivity helps to reduce ghosts and images caused by unwanted signals.

DIRECT AND REFLECTED WAVES

The effect of large masses of conductive material on radio waves can play havoc on TV signals. The best signal occurs when there is a direct and unobstructed path between the station and your TV set. This is called "line-of-sight" operation (Figure 1-5.).

MULTIPATH SIGNALS

There may be a direct path between you and the TV station, but if there is a large mass off to one side (Figure 1-6) you may get two signals, one direct and one bounced off the large mass. Although radio waves travel 186,000 miles per second, there is a slight delay in time between the two signals because of the longer path of the second one, so one signal is received later than the other. This gives rise to ghosts in your picture—another image slightly to the right of the main image. The large mass may be another high building, a

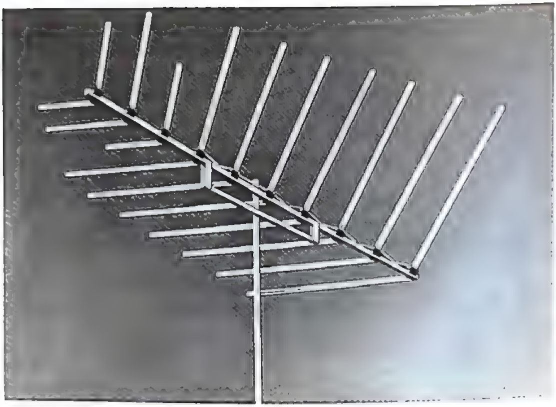


Figure 1-4. A multi-element TV antenna.

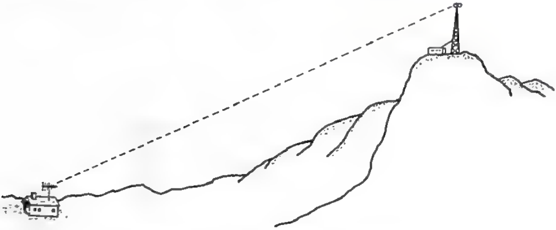


Figure 1-5. Line-of-sight-transmission.

mountain, a water tower, or any other large object that is electrically conductive. This is the reason for the importance of using highly directive TV antennas at the receiving end. They reduce, and sometimes even eliminate, the reflected signal. We will discuss this in more detail in a later chapter.

Sometimes a large building will be in the direct path and a hill produces a secondary path with just as strong a signal, or even stronger. In this case it may even be preferable to point the TV antenna in the direction of the indirect path and eliminate the poorer direct signal. But only a highly directive TV antenna will do this.

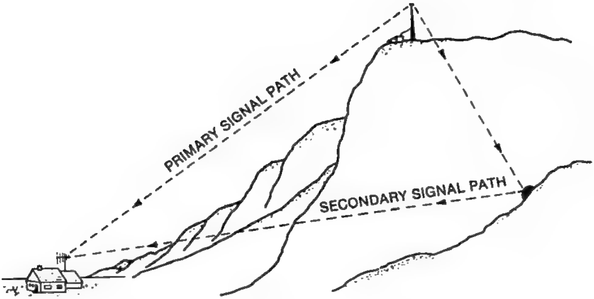


Figure 1-6. Secondary path can produce ghosts.

CHAPTER 2

TV ANTENNAS

TV antennas must be designed to receive a very wide band of frequencies for the many TV channels, and receive them with highest possible efficiency. The antenna engineers must be honored for developing today's design which makes possible such wide-band coverage, along with high unidirectional characteristics and high sensitivity. To see the engineering behind an antenna, let us look briefly at the TV channel frequencies.

Table 2-1 lists the VHF TV channels and the actual frequencies of the picture signals. Each TV channel also carries a subcarrier for sound. It is set at just 4.5 MHz higher than the picture carrier frequency. In addition, a color subcarrier is 3.58 MHz higher than the picture-carrier frequency. UHF TV channels from 14 to 83 are in the frequency range from 470 MHz to 890 MHz.

VHF AND UHF ANTENNAS

It becomes obvious that a single antenna of the single element type cannot possibly cover all the frequencies being transmitted on all the TV channels. Not only is each TV channel very wide in frequency needs, but add to that the many channels and the problem is increased.

Full coverage of the wide frequency spectrum is achieved by the use of more than one element on a single boom. Each element is of a different length, so the combination of all of them results in good coverage.

The four diagrams in Figure 2-1 carry us through the evolution of a four-element VHF antenna. Diagram A shows a single element called the half-wave dipole. In diagram B another element is added, but of a longer length. This second element resonates at a lower

Table 2-1. VHF Channels, Carriers, and Subcarriers*

Channel	Frequency Limits	Picture Carrier	Color Subcarrier	Sound Subcarrier
2	54-60	55.25	58.83	59.75
3	60-66	61.25	64.83	65.75
4	66-72	67.25	70.83	71.75
5	76-82	77.25	80.83	81.75
6	82-88	83.25	86.83	87.75
FM	88-108	—	—	—
7	174-180	175.25	178.83	179.75
8	180-186	181.25	184.83	185.75
9	186-192	187.25	190.83	191.75
10	192-198	193.25	196.83	197.75
11	198-204	199.25	202.83	203.75
12	204-210	205.25	208.83	209.75
13	210-216	211.25	214.83	215.75

* All frequencies in megahertz

frequency and also acts as a reflector for the shorter element. In diagram C a still longer element is added for a still lower channel (or lower frequency), and it becomes a reflector for the shorter element in front of it. In diagram D a fourth and still longer element is added. It becomes a reflector to the shorter element, as well as resonating near the low-frequency end of the low-section VHF band, or near Channel 2. To aid in the directivity of this antenna, the elements are bent forward.

The illustration in Figure 2-1 shows each element connected to the lead-in, in a system called cross-phasing. In some antenna designs, director and reflector elements are added but not connected to the lead-in.

The FM band at 88 to 108 MHz is just above TV Channel 6 in frequency. The broad TV antenna coverage includes the FM band. A

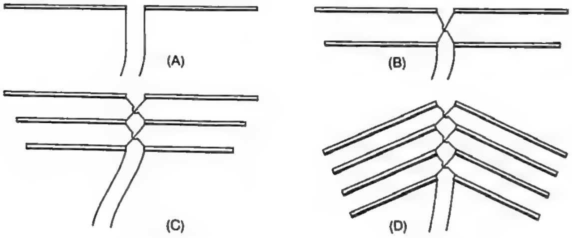


Figure 2-1. Evolution of a TV antenna from a simple dipole.

TV antenna will also operate an FM tuner or receiver, and it is common practice to take a tap off the lead-in to serve both a TV set and FM tuner or receiver.

The UHF bands are considerably higher in frequency than the VHF bands. While the frequency range is not broken up into sections as with the VHF band, they are divided into two parts for two types of service. Channels 14 to 70 (about 470 MHz to 812 MHz) are for regular TV broadcasts. Channels 71 to 83 (about 812 MHz to 890 MHz) are for translator service. Translators are located in smaller communities and act as relays for programs originating in a nearby metropolitan city. They are automatic in operation; that is, they are unmanned. Thus, communities too far from regular TV stations have TV service.

It is obvious the antenna described earlier in this chapter would operate poorly in the UHF band. The elements are much too long to be resonant to the much higher frequencies of the UHF band. Coverage of the UHF band is accomplished by adding a separate section to the same boom.

Figure 2-2 is an example of an all-coverage antenna, one that receives VHF, FM, and UHF with high efficiency. Note the odd-looking front part of the antenna. This part has the short elements needed to resonate at UHF. The engineering behind it is generally the same as for the VHF part of the antenna. Usually more elements are used, because the overall frequency coverage is greater, and more sensitivity is needed to overcome the greater losses encountered at such high frequencies.

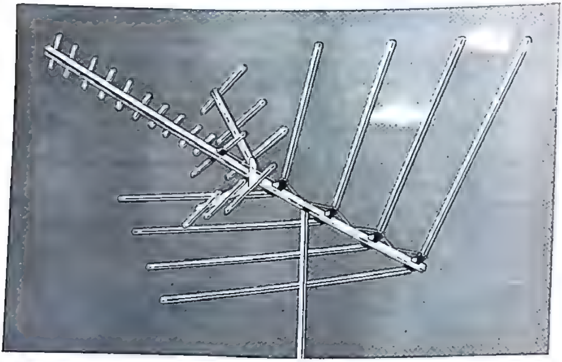


Figure 2-2. An all-channel TV antenna with separate VHF and UHF elements.

Losses are somewhat greater at UHF than at VHF, both in the transmission and the reception. Hills, trees, terrain, and other obstructions affect the transmission more at UHF than at VHF. Television set sensitivity is less at UHF. Losses are greater in the lead-in. This is why distance specifications on TV antennas are less for UHF than for VHF.

Where UHF translator TV service only is available, it is uneconomical and unnecessary to invest in a full-coverage VHF-UHF antenna. Television antennas and equipment for the reception of the UHF channels only are available.

The UHF end of the antenna illustrated in Figure 2-2 can be purchased separately. This is shown in Figure 2–3.

COLOR TV ANTENNAS

The requirements for feeding a signal from the antenna into a color set are quite different than for a black and white set. The color information is carried on a subcarrier of 3.58 MHz on the picture frequency. Good signal strength is needed to receive this subcarrier with all its color information. A weak signal would result in a black and white picture on a color set, along with some "snow."

If you live some distance from a TV transmitter you might tolerate some snow on a black and white set, but you would never be happy with receiving only a snowy black and white picture on a color TV set. The extra investment made in a color TV set dictates an extra investment in a good antenna to assure reception of color TV signals. Furthermore, don't skimp on a proper installation. Selection and installation are covered in separate chapters which follow.

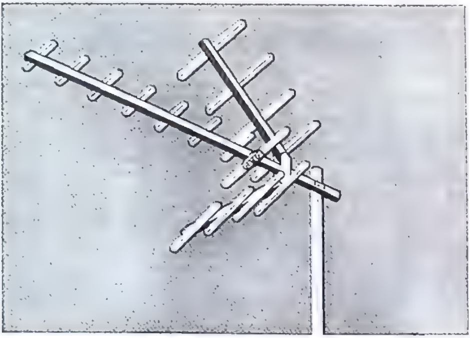


Figure 2-3. TV antenna for UHF reception only.

CHAPTER 3

SELECTING THE PROPER TV ANTENNA

Probably the most important consideration in selecting an antenna, but certainly not the only one, is how far your house is from the TV transmitter. As explained in Chapter 1 the strength of the signal drops off rapidly with distance from the station. The signal at 20 miles from the station is only one-fourth the strength of that at only ten miles. This is the effect of the "inverse square law." With normal city dwellers, however, distance from station is not that important. In most cities the transmitting antenna is usually located on top of a centrally located high building, or on top of a nearby mountain or hill.

If you are in "line-of-sight" distance from the transmitting tower from your house even a minimum sized antenna may do the job quite well. If you are able to see the transmitting antenna, with no buildings or trees or other major obstructions, you are enjoying the best possible conditions. But there are other factors which may affect your decision on what antenna to buy.

In the opposite direction, close in and "line-of-sight" will permit quite satisfactory results with one of the better indoor antennas, like that shown in Figure 3-1. See Chapter 8 for more on indoor antennas.

TO ELIMINATE GHOSTS

A ghost is one or more images appearing next to the main image on the TV set screen. This results when part of the TV signal is delayed in getting to your set, and the lag in time of arrival means another image, slightly offset from the first, will be included in the picture received.

This so-called "multipath" signal will happen when part of the transmitted signal hits some high point such as a mountain or large

Figure 3-1. A deluxe indoor TV antenna.

building near the transmitter, and reflects some of the signal out to your receiving position. Figure 3-2 shows an example of this. The secondary path being longer, the secondary signal takes a little longer to reach your TV antenna. The extra length of that path determines how far the "ghost" picture on your screen is displaced from the main picture. TV antennas with a more highly directional characteristic will receive the secondary signal path with less strength and thus reduce, and sometimes eliminate, the effect of ghosting. Antennas with more elements on them are more directional. Figure 3-3 is a polar pattern of a typical highly directional TV antenna. The outline of the figure represents points of equal signal strength. In this example a signal only about six or seven degrees off the main path would have to be half the distance from your antenna to be of equal strength to the main signal path.

Probably the best way to determine in advance if ghosts may be a problem at your location is to ask your nearby neighbors about their experience.

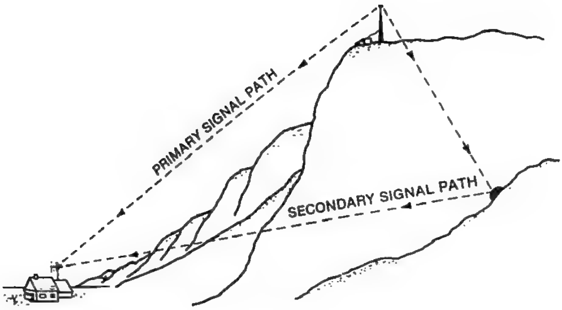


Figure 3-2. Delayed signal from secondary path can produce ghosts.

Another factor affecting an antenna purchase is the number of TV and/or FM sets that are to be operated from the one antenna. In today's multiset homes it is not necessary to purchase separate antennas for each set. There are distribution transformers or couplers that make it possible to connect any number of sets to one antenna, with only one important effect—the available signal power received is divided among the number of sets connected. This means

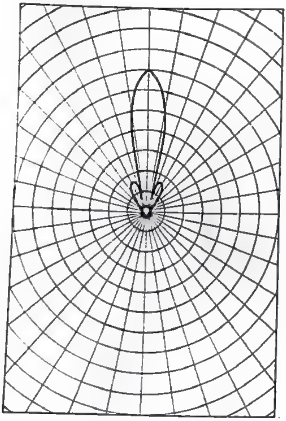


Figure 3-3. Polar pattern of a highly directional antenna.

a larger antenna should be used, to assure there will be enough signal strength for each set. The FM band falls between the low and higher VHF TV bands. A TV antenna can also serve an FM receiver or tuner by using one of the outputs of a coupler, the same as another TV set.

The height of the antenna above ground adds a great deal to its ability to receive signals from a distance. In city and suburban areas it is usually sufficient to just mount the antenna on top of the house, or even in the attic. Homes in the country, on the farm, or ranch distant from the transmitting antenna pose a different problem. There, height becomes very important and often requires the investment in a 50-foot or higher tower. It may even require the addition of amplifiers to boost the signal. More about these later.

Table 3-1. Specifications on Archer TV Antennas

Archer Model	Range in Miles			Boom Length	No. of Elem.	Cat. No.
	VHF	UHF	FM			
VU-190	190	120	100	160"	48	15-1646
VU-160	160	100	100	140"	40	15-1645
VU-120	120	90	90	120"	35	15-1644
VU-110	110	90	90	100"	30	15-1643
VU-90	90	70	70	80"	25	15-1642
VU-75	75	50	50	50"	17	15-1641
VU-60	60	40	40	40"	13	15-1640
V-185	185		110	160"	34	15-1654
V-110	110		80	80"	14	15-1652
V-90	90		60	50"	10	15-1651
V-60	60		40	30"	6	15-1650

Another factor in antenna choice is the TV bands in use in your area. If TV service is only in the band which covers channels 2 through 13 a VHF antenna like that shown in Figure 3-4 will do. In some cities the UHF station or stations are not at the same location as the VHF stations, but in a different direction altogether. That means you may need to install a second antenna, one which serves the UHF channels separately (Figure 2-3).

Rotators are often used on TV antennas to turn them to a different direction. Homes in the country may need a rotator when TV reception is from cities in different directions. Antennas with greater signal gathering ability are also more directional in characteristic, so they must be turned in the direction of the transmitter to pick up the signals.

Radio Shack makes it easy to select a TV antenna by their model number designations and by charts published in the catalog. Reproduced in Table 3-1 are the figures from their charts. The

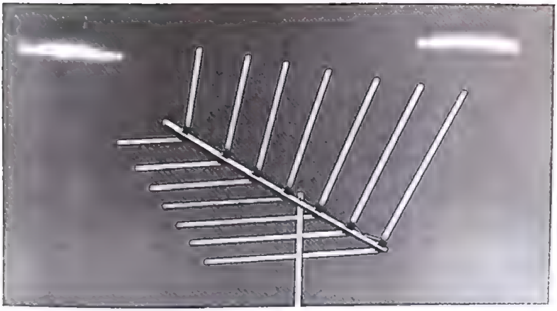


Figure 3-4. A VHF-only TV antenna.

Archer brand model numbers are preceded by a VU for antennas for both VHF and UHF signals, a V for antennas designed only for Channels 2 through 13, and a U for antennas for UHF use only. The numbers following the letters are the approximate miles the antenna will reach for good signal reception. The figures apply to the use of one antenna for one TV set. When the signal must be divided among more sets, or to include an FM tuner or receiver, an antenna with a higher figure should be used.

Note from the charts, maximum range in miles is related to both boom length and number of elements. In the case of the VU models the number of elements include those in the UHF part of the antenna structure. Note, also, the distances covered are less for UHF and FM services. Frequencies in the UHF range are so high that losses in signal transmission, in lead-in cable and other factors, call for longer booms and more elements for the same distance of coverage. For FM reception a strong signal is needed to supply good stereo separation.

CHOOSING THE ANTENNA

The mileage coverage shown in Table 3-1 for Archer antennas presupposes nearly line-of-sight locations between the transmitting and receiving antennas. Obviously you would not be expected to actually see a transmitting antenna 160 miles away, but one can assume it is in line-of-sight if on top of a high mountain at that distance. If the transmitting antenna is not on a high mountain, but on a building that is, say, only about 10 stories high, the horizon

between you and the transmitter reduces line-of-sight effectiveness. Considering the investment on one or more color TV sets to work from the antenna, it is better to err in favor of a larger antenna since the increased cost of the antenna is only a small part of the total investment in good TV reception. As an example, if you are 50 miles from the transmitter and there is not true line-of-sight conditions or you are in doubt, select an antenna with a 100 mile figure or greater.

When obstructions are in the way there is great loss of signal. Should there be tall buildings in the signal path, or heavy trees, the loss would be greater in summer when the trees are in full leaf. In such cases the antenna to select should be two steps above the idealized one on the basis of mileage.

Attics sometimes have the space to hold an antenna, and some people prefer to use it. Because of the lower height, and the usual obstructions associated with the use of an attic, select an antenna one or two steps above the minimum.

For UHF and FM reception, the mileage figures are shown separately in the charts. However since the FM set represents another hookup to the antenna, an antenna of double the mileage figure shown should be selected.

Where multiple sets or TV sets plus FM tuner are to be operated from the same antenna, couplers should be used to divide the signal among them. While couplers are the most efficient way of dividing the signal there is some signal loss in couplers. Divide the distance figure by the number of sets to be connected to the antenna to select the mileage figure that applies.

Ghost images are probably the biggest bugaboo in the reception of good quality pictures. Even transmitting antennas on top of high mountains are not always the answer. The signal can bounce off another nearby mountain and result in a multipath signal. Only the experience of others in the neighborhood can be of assistance in selecting the proper antenna. The greater the number of elements in an antenna the greater its directivity, and directivity is the most important quality needed to reduce ghost images. It is sometimes necessary to make some adjustments on the direction to which the antenna points at the time of installation. There are occasions where better overall results are obtained when the antenna is pointed slightly to one side of the direct path because it may reduce the reflected path to a greater degree and overall results are much better.

TV FOR RECREATIONAL VEHICLES

For the family on the go there is an antenna in the Archer line especially suited for them. Figure 3-5 shows a standard design TV

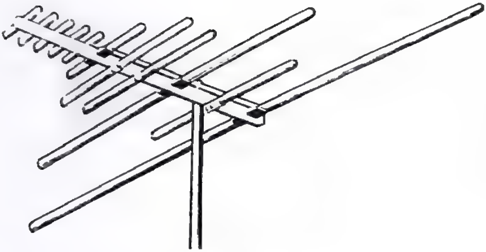


Figure 3-5. Mobile TV antenna. Elements fold down for traveling.

antenna with elements for VHF, FM, and UHF. It is supplied as a complete kit with all necessary hardware for mounting the antenna to the side of the RV. The antenna folds down while traveling to reduce wind resistance, and snaps up for operation. Turning for direction orientation is done by hand.

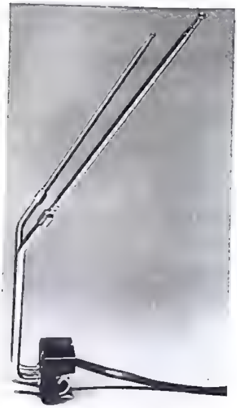


Figure 3-6. Mobile VHF-TV antenna.

An Archer line VHF-TV antenna for vehicles on the move is shown in Figure 3-6. This allows passengers to enjoy reception in limos, cars, vans, and trucks while traveling. In areas of weak FM reception, this could also be used to improve the FM signal.

CHAPTER 4

SPECIAL ANTENNAS FOR FM

The FM frequency band range is 88 to 108 MHz. It starts just off the high frequency end of TV Channel 6. That is why a TV antenna also receives FM signals quite well, and the same antenna can be shared between a TV set and an FM tuner or receiver.

THE RESONANT ANTENNA

Since the FM band is only 20 MHz wide, an FM antenna of simple design can be considered pretty nearly resonant in the FM band. This is why a single element antenna, or single dipole as it is called, does a good job of FM reception. A dipole about 60 inches long is considered resonant in the FM band. At this length it becomes a half-wave dipole, the usual term used in engineering parlance for the simple resonant antenna. Figure 4-1 is a drawing of such an antenna.

UNIDIRECTIONAL AND OMNIDIRECTIONAL ANTENNAS

Too often FM transmitting towers are not all located in a single area, as mentioned before. Where this is true, good reception from all stations requires an antenna that has good pickup from all directions. This type of antenna is called an omnidirectional or polydirectional antenna.

The antenna illustrated in Figure 4-1 would have a polar pattern that would look like a figure 8 (Figure 4-2). It would be good for pickup in the two opposite directions. The antenna of Figure 4-3 is two folded dipoles at right angles to each other. The polar pattern becomes two figure 8's at right angles (Figure 4-4). Now we have essentially an omnidirectional antenna. In practice the patterns

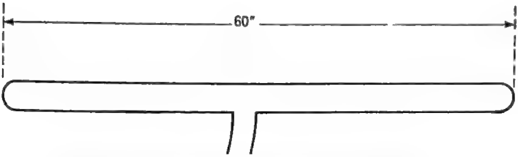


Figure 4-1. Folded dipole antenna for FM band.

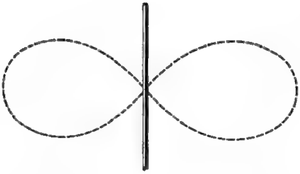


Figure 4-2. Pickup pattern of single dipole antenna.

illustrated are never exact, as they are affected by surrounding terrain and other conductive objects and nearby wire systems.

Figure 4-5 is another omnidirectional antenna. As can be seen, the antenna is a single dipole but bent into an "S" curve. This will distort the normal figure 8 pattern and result in good omnidirectional pickup. The antenna of Figure 4-3 is to be preferred for best all-around pickup.

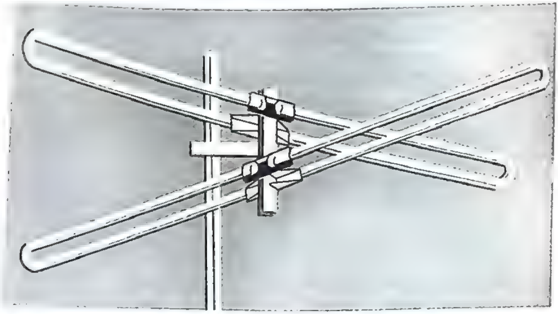
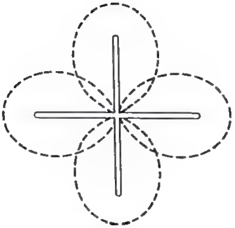


Figure 4-3. FM antenna with two folded dipoles set at right angles.

Figure 4-4. Polar pattern of antenna shown in Figure 4-3.



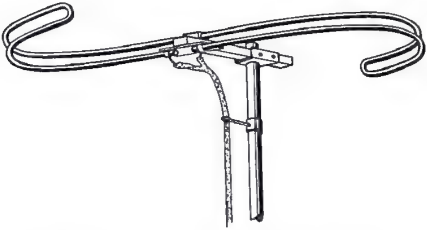


Figure 4-5. S-curve omnidirectional FM antenna.

STEREO RECEPTION AND ANTENNAS

If you have a good FM tuner or receiver you probably know it has a published sensitivity somewhere between 0.5 μV and 5 μV. This is a considerably higher sensitivity figure than for TV sets. This means that just about any old piece of wire connected to the antenna terminal will give you good enough reception, and often does. But "good enough" is not good enough when it comes to hi-fi stereo reception.

As in the case of color TV transmission with its 3.58 MHz subcarrier, the FM signal includes a subcarrier of 19 kHz. This subcarrier carries the multiplexing information needed in the receiver or tuner to separate the two channels of audio with a minimun of overlap. This 19 kHz signal is transmitted at one-tenth of the FM modulation. If the subcarrier is lost in reception the stereo will be lost or so degraded that good separation of the two audio channels is not "hi-fi." In other words the two channels of audio will not be separated, but heard as a monophonic or single-channel audio. Sometimes the signal is borderline and the stereo effect falls in and out as you listen, and this can be most distressing.

Furthermore, good noise reduction from both external and internal noises (circuit noises) requires a good strong signal at the input to be really effective. So, what it comes down to is that in spite of the high sensitivity of good tuners or receivers, it is still necessary to receive a strong signal for high-fidelity results. Figure 4-6 is an example of a multielement antenna design that will provide the signal strength needed for good stereo FM reception. It is designed, of course, to provide FM reception at a great distance as well, having a range of 175 miles. A similar antenna but with less elements has a range of 110 miles.

The multielement antennas described above have another, and very important, advantage. These antennas are also highly directional and this is an important characteristic for FM. In the case of TV a multipath signal will result in a ghost image on the picture tube. In the case of FM it results in distortion. The radio waves radiate out in all directions from the transmitting antenna. If there is a high hill or a building nearby some of the signal will bounce off the hill or building and create a secondary wave. The secondary wave path from the transmitter to your location is longer and takes a bit longer to reach your antenna. Because of this there is a phase lag between the direct and indirect signals and this can result in what engineers call phase distortion. As in the case of TV a highly directional antenna at the receiving end will reduce or eliminate this effect.

The very best FM reception is provided by the use of both a highly directional antenna and a rotator. The rotator not only allows you to

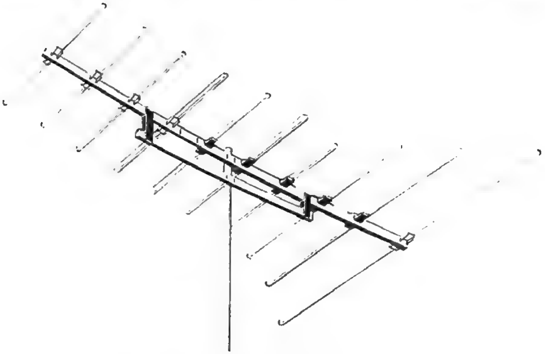


Figure 4-6. A highly directional FM antenna.

swing the antenna in the direction of the FM transmitter, but also permits slight adjustment of the antenna direction for maximum reduction of secondary path signals. Very often aiming the antenna just a couple of degrees off the actual direction from the wanted path will have a great effect in reducing the signal from the secondary path, and reducing distortion.

Chapter 5

FRINGE AREA TV/FM ANTENNAS

The word fringe means the outer area of good TV reception, beyond which enjoyable reception should not be expected. It may be defined as somewhere between 100 and 150 miles, the extremes of which might be named near fringe and deep fringe. The words are rather nebulous and even the distances are not clear, as so much depends on other factors and not just distance. Conditions of terrain count as much as distance.

DISTANCE AND SIGNAL STRENGTH

In Chapter 1 we discussed the similarity between light and radio waves, and the loss of signal based on the inverse-square law. Signal loss is related to the square of the distance. At 50 miles a signal is only one-fourth as strong as at 25 miles. At 100 miles it is only *one-sixteenth* as strong as at 25 miles. The sketch of Figure 5-1 is

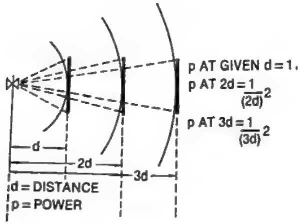


Figure 5-1. The inverse-square law.

another method of showing this. To make an even more extreme comparison, city folks living at about 10 miles from a TV transmitter have no problem with TV reception on the basis of distance only. Their "country cousins" living 100 miles from the same transmitter are faced with receiving a signal only one-hundredth as strong, so they must take special steps to make the best of that weak signal.

The inverse-square law is based on free-space conditions; that is, with nothing else interfering. But at the surface of the earth other things do interfere—the horizon and hills or rolling terrain.

Light bends very slightly around the curvature of the earth. The prism effect of the denser atmosphere near the surface and lighter atmosphere higher up is what puts a small bend in light. Radio waves will follow the curvature of the earth much more than light waves, for reasons other than the prism effect of the atmosphere. At low radio frequencies the bend is considerable. This is why you can pick up broadcast stations at night a thousand or more miles away from your car radio as you travel across country. (Long distance transmission is better at night due to rearrangement of the ionized layers.) At higher radio frequencies, radio waves begin to act more and more like light, and the ability to follow the curvature of the earth is less. At TV frequencies the bend is quite small. Hills and other rises in the earth's terrain are even more difficult to overcome. This is why great height is needed, both on the part of the TV transmitter and on the part of the receiving antenna.

A homeowner at a distance from a TV transmitter and in a valley has an almost insurmountable problem in bringing TV entertainment into his home. An individual can install an antenna at the top of a nearby hill, connect an amplifier, and run coaxial cable down to his home. This becomes a rather expensive installation. Communities in a valley will usually contract for a community television installation and service. This is called CATV. A company will install a very high-gain antenna on a hill, amplify the signal from it, and feed the signal to the homes in the community by coaxial cable. A fee is charged to bring the cable into the home, and a monthly service charge helps maintain the equipment.

These days greater use is made of satellite TV transmitters, called translators. They are usually installed in smaller communities by the operators of principal TV stations in a larger city. The main TV station uses microwave transmitters to send their programs to the translator, which then retransmits the programs to a local area. Translators are usually low in power, but cover the local community. They are maintained by subscription from local residents. Not all communities in a state-wide area are covered by translators. Translators are usually operating on Channels 14 to 70, in the UHF range.

LONG-RANGE ANTENNAS

To assure good fringe area reception of TV, a high-gain antenna mounted as high as possible is required.

The antenna in Figure 5-2 is an example of an all-coverage antenna for fringe use. It covers the VHF and UHF TV bands as well as FM. With a total of 40 elements it will receive TV signals on the VHF band up to 160 miles, and on the UHF and FM bands up to 100 miles.

If the TV stations around you broadcast service in Channels 2 to 13 only (the VHF TV band), the antenna in Figure 5-3 has more gain than the one in Figure 5-2 and at less cost. With its 34 elements it will bring in TV signals from up to 185 miles, and FM up to 110 miles.

In many areas, stations serving the fringe areas transmit only on the UHF channels, 14 to 70. Also, sometimes the UHF translators on Channels 71 to 83 will be quite a distance from your home. In any case, the UHF antenna in Figure 5-4 is a UHF-only TV antenna capable of picking up signals in the UHF channels up to 100 miles away. It is highly directional.

NEED FOR HEIGHT

The one factor for successful reception of TV in fringe areas, that of high-gain antennas, was described above. The other factor is the need for great height to overcome the effect of the horizon or other hilly obstructions. Height is important for both the transmitting and receiving antennas. The TV stations use the highest economical

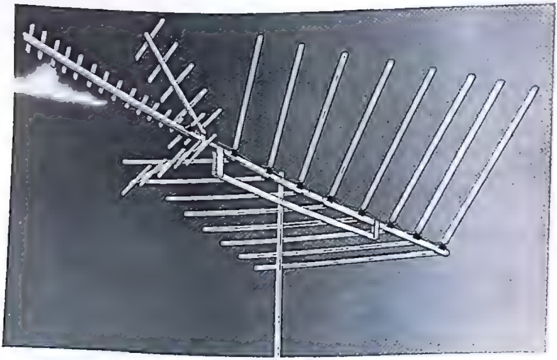


Figure 5-2. A 40-element all-channel TV antenna.

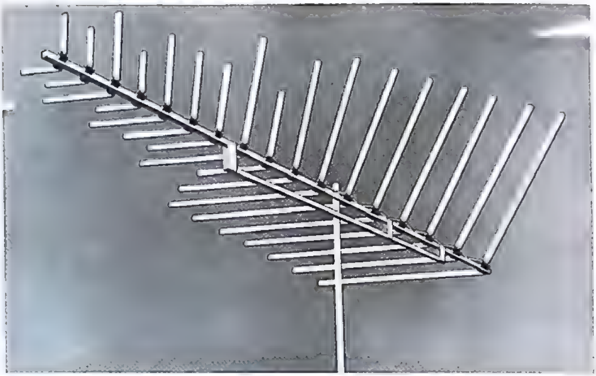


Figure 5-3. A 34-element VHF-only TV antenna.

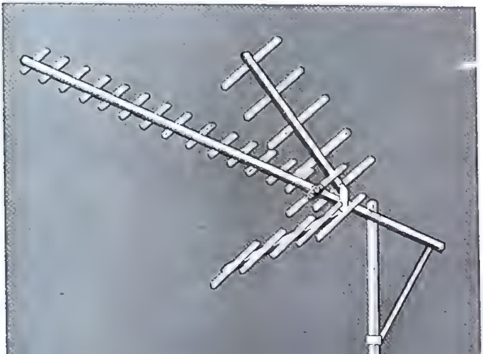


Figure 5-4. A long range UHF TV antenna.

locations they can in order to serve as many viewers as possible. The height of the receiving antenna is up to the owner of the TV set.

One of the best ways of deciding just how much height is needed for your location is to check with neighbors in your area. However, keep a few points in mind when checking with your neighbor. Is he using a black and white set? How much snow, if any, is there in the picture? How does the antenna compare with the one you plan on installing? Is he located on higher ground than your location? If you want a good color reception, you will need a better installation than one for black and white.

MASTS AND TOWERS

The usual method for installing a TV antenna at great height is atop a mast or tower. Masts, like the one shown in Figure 5-5, come in 19-, 27.5-, and 36-foot lengths. They are made in sections with graduated diameters that telescope into each other. The steel masts are hot-dipped galvanized and zinc coated for weather protection.

A steel stake and plate is used to keep the mast from sinking into the ground or moving horizontally, see Figure 5-6.

Towers are triangular or square-shaped structures with cross

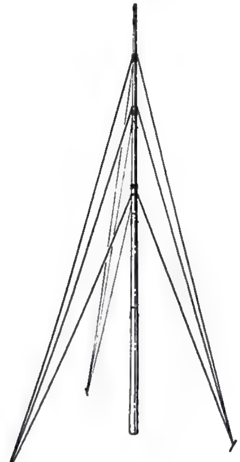


Figure 5-5. Telescoping steel mast.

girders. They are usually made of steel. They are considerably more expensive than masts.

It is extremely important in the installation of a mast or tower to be sure it will withstand the highest possible wind that may be encountered in your area. Highest winds normally encountered are about 80 miles per hour, with some exceptions. The exceptions are along the Atlantic seaboard and the coastal borders of the states along the Gulf of Mexico. In Wisconsin, along the shore of Lake Michigan, winds are known to exceed the 80 miles per hour mentioned.

It is always best to include a safety factor. A 30% safety factor is recommended by the Electronic Industries Association, which means for highest normal 80 mile-an-hour winds, figure on about 110 miles per hours.

Towers up to fifty feet can usually be installed without guy wires. A three-foot square hole is dug. The mounting feet usually supplied with the mast are put in place, properly spaced to fit the bottom of the tower, and about a yard of concrete is poured into the hole. When the concrete is set, two of the bottom feet of the tower are fastened to the mounting feet, and the tower pulled up into place. Steel towers are quite heavy, and will probably require the use of a gin pole, a tackle line, and two or three husky men to put them up (Figure 5-7).

Masts are not only less expensive, but considerably lighter in weight. A 36-foot mast only weighs about 30 pounds. All masts must be guyed, which means there must be enough room around the mast location for the guying stakes. Guying stakes should be placed about 10 feet from the base for each 20 feet of mast height. Radio-type, 6/18 guy wire is sufficiently strong to hold a 36-foot mast in any wind. Size 6/18 means six strands of size 18 galvanized iron wire twisted together. Stakes may be commercial type such as used for anchoring fences or guying telephone poles, see Figure 5-8, or steel fence posts driven into the ground to within a few inches of the top.

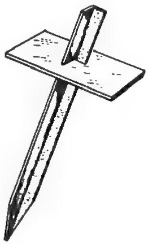


Figure 5-6. Mast base mount.

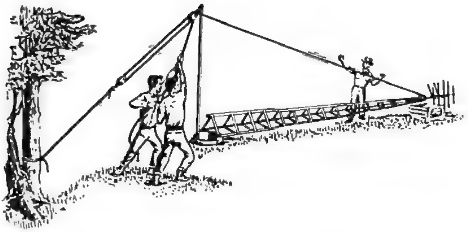
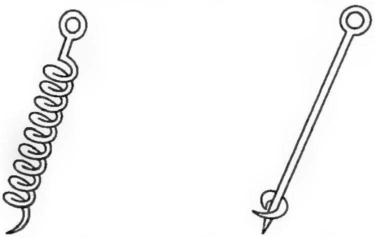


Figure 5-7. Using a gin pole to raise a TV tower.



(A) Screw type.

(B) Auger type.

Figure 5-8. Screw-in guy-wire anchors.

Masts are light enough to be mounted on the roof of a house or other structure. It requires careful calculation of the length of the guy wires, which are fastened in place before the mast is raised onto the roof. Figure 5-9 shows how this is done. The mast can be walked up after the guys are in place. Be sure the guy eye-screws are fastened into roof rafters, or they will surely pull out with a high wind.

The TV antenna, and rotator if used, must be installed on the tower or mast before they are raised. All lead-in and rotator cables must be connected and run down with standoff insulators beforehand. The antenna must be correctly oriented if a tower is used, as a tower cannot be rotated after it is up. A mast, however, can be rotated after it is in the vertical position.

If TV transmitters are located in different directions, or if an offside hill develops a secondary signal path, a rotator is highly recommended. Rotators are geared-down, electric motors that turn the antenna to the direction desired.

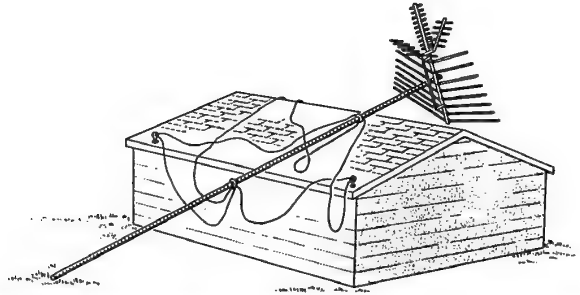


Figure 5-9. Setup of TV mast preparatory to walking it up to the peak of the house roof.

An important precaution: Be sure to install your antenna far enough from any electric lines so that it will not fall onto the lines in case it is blown down. Also consider any possible damage to buildings or other structures nearby, either those of your own, or those of your neighbor's. Leave plenty of room around your antenna system.

To make a secure guy-wire connection be sure to use two or more wraps around the eyelet and then at least 10 or more tight turns around the guy as shown in Figure 5-10.

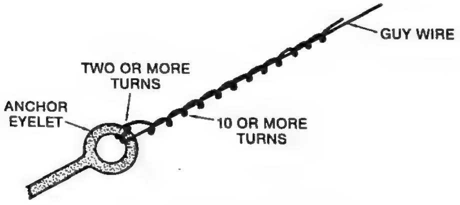


Figure 5-10. Guy-wire connection.

Another method of guy wire connection makes use of guy-wire clamps as shown in Figure 5-11. When using these clamps, be sure the "U" bolt compresses and deforms only the short free end of the guy-wire. This keeps the strength of the guy wire at its maximum. Large size guy-wire which is difficult to twist tightly around itself should use guy-wire clamps as shown in Figure 5-10.

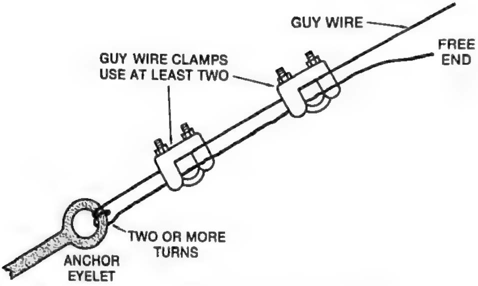


Figure 5-11. Guy-wire connection using clamps.

When using a high antenna installation, you will need longer 75- or 300-ohm lead-in. Don't make the common mistake of using normally bad cable. Use the best grade of low-loss cable you can afford or all your increased signal pickup will be lost in the cable, and the entire effort will be to no avail. Some older installations suffer from no more than lossy lead-in.

If TV transmitters are located in different directions, or if an offside hill develops a secondary signal path, a rotator is highly recommended. Rotators are geared-down, electric motors that turn the antenna to the direction desired.

An important precaution: Be sure to install your antenna far enough from any electric lines so that it will not fall onto the lines in case it is blown down. Also consider any possible damage to buildings or other structures nearby, either those of your own, or those of your neighbor's. Leave plenty of room around your antenna system.

CHAPTER 6

MULTIPLE-SET DISTRIBUTION

More and more homes now have two or more sets. Two-set homes may nearly equal, if they do not already exceed, the number of homes with one TV set. Also operating an FM tuner or receiver off the same antenna with a TV set is quite popular.

Assuming a reasonably good antenna and a reasonable distance from the TV station, along with the high sensitivity of the modern TV set, there is no reason why more than one set cannot be operated from a single antenna. In doing so, however, it is advisable to observe certain rules for best results.

IMPEDANCE MATCHING

When the impedance rating of the antenna is equal to the lead-in impedance, there is a maximum transfer of power. This is also true for the end of the lead-in where maximum power transfer is also dependent on equal line and termination impedances. Any condition which upsets this required impedance match will cause less power transfer at both the source and termination of the line, and an increase in loss of energy all along the line. For these reasons, the impedances must always match or the installation may waste so much energy that proper reception would be impossible on one or more stations. Figure 6-1 shows an improper connection of two TV sets on a 300-ohm lead-in. Each set presents a load of 300 ohms, so the net load effect on the line at the table model TV is 150 ohms, as shown in Figure 6-2. This analogy of two parallel resistors illustrates the mismatched impedance on the load end of the lead-in, but this improper connection also causes a mismatch at the antenna. This antenna-to-line mismatch depends on the length of line and the frequency of the signal. The full effect of a mismatch like this cannot be illustrated simply.

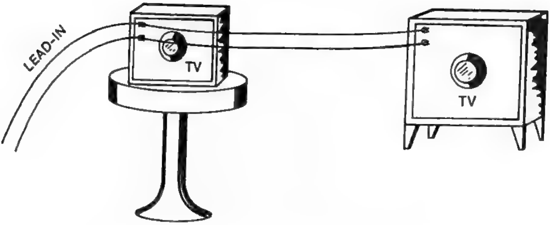


Figure 6-1. Improper connection to two TV sets.

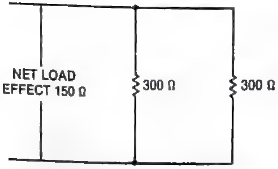


Figure 6-2. Schematic representation of Figure 6-1.

Impedance matching is obtained by the use of RF transformers in the same way PA speakers are matched with audio transformers. These RF transformers are generally about 90% efficient so loss in them is much less than would occur if they were not used. RF transformers are commonly called splitters or couplers, depending on their application.

Two types of impedance-matching couplers are generally available. Figure 6-3 shows a two-set coupler. It has three sets of screw terminals. One set is for connecting the lead-in. The other two are for the two sets. The same kind of 300-ohm lead-in wire may be run from the coupler to the TV sets. This is the way it is usually done, with the coupler located somewhere convenient to both sets. Figure 6-4 shows a four-set coupler. The five sets of terminals are for the lead-in, and

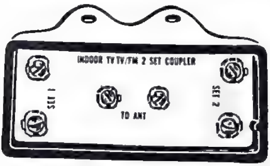


Figure 6-3. Two-set coupler divides the single input signal to two output signals.

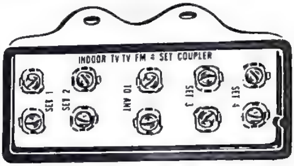


Figure 6-4. A four-set coupler.

for the wires to the four sets. It should be located where a distribution cable to each set can be kept to a minimum length.

Figure 6-5 shows how to connect a two-set coupler. The coupler itself should be located at a point where it results in a minimum overall amount of cable run. If in-the-wall lead-in installation is used, a good place for the coupler is in the attic. The same hookup is used for a TV set and an FM tuner, substituting the tuner for one TV set.

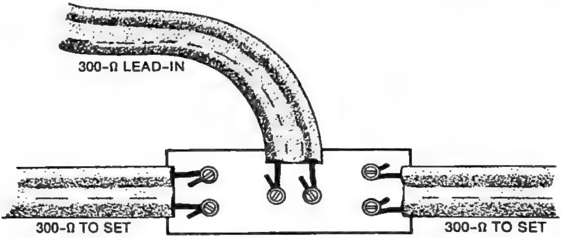


Figure 6-5. How to connect a two-set coupler.

What do you do when you want to connect to only three TV sets, or two TV sets and an FM tuner? Use a four-set coupler. However, it is best to connect a "dummy load" to the fourth terminal set. All this means is to connect a 300-ohm 5%, or 270-ohm 10% value resistor to the terminals. While this results in a waste of some of the power, it does maintain the impedance match. These resistors may be purchased at Radio Shack.

Figure 6-6 shows the hookup for a four-set coupler. In this diagram three TV sets and an FM tuner are connected to the coupler, and all are operated from a single antenna. Figure 6-7 shows what a resistor looks like. To substitute the resistor for a TV set, merely bend the two leads of the resistor, twist one lead around each of the screw terminals of the unused set (Figure 6-8), and tighten the screws.

Figure 6-6. Connecting three TV sets and an FM tuner to one antenna.

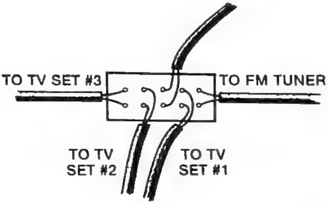


Figure 6-7. An oversize view of a typical carbon-composition resistor.

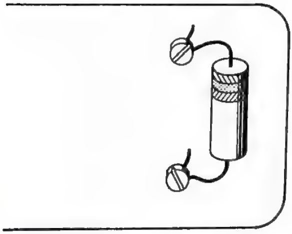


Figure 6-8. How a resistor is connected across an unused coupler output.

Multiple-set distribution to 75-ohm color TV sets using coaxial cable follows the same rules as for 300-ohm cable described above, except the figures are in terms of 75-ohm impedances to be matched. Figure 6-9 illustrates a four-set coupler for 75-ohm coaxial cable. Instead of screw terminals cable connectors are used. The cable ends must include mating plugs on them at each end of each cable. Cables already prepared with connectors on them are available in 2-, 4-, 8-, 50-, and 100-foot lengths. You can make your own by purchasing bulk 75-ohm coaxial cable and the plug connectors.

Multi-set couplers must not have empty output connectors. As in the case of the 300-ohm type couplers, where a 300-ohm resistor is connected to the unused screw terminals, the coaxial-type couplers

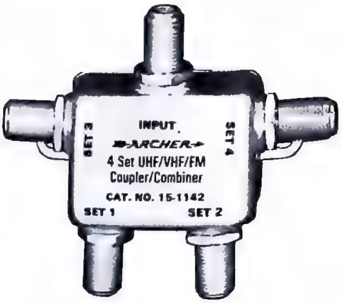


Figure 6-9. Four-set coupler for 75-ohm coaxial cable.

must use 75 ohm 5%, or an 82 ohm 10% value, connected to empty connectors. Use a coaxial plug and install a 75-ohm resistor. One lead of the resistor will be the inner conductor by passing it through the center hole; the other lead is wrapped around the outer shell and soldered to it. Leave only about 1/4" of center lead sticking through the center, cutting off the rest.

300-ohm and 75-ohm cables and how to connect a plug to 75-ohm cable are illustrated and described at the end of the next chapter.

Sometimes conditions are such that it is more convenient to place the coupler outdoors and run separate lead-in wires into the house to the individual sets. Figure 6-10 shows a two-set splitter/coupler, but in a weatherproof housing, and with clamps for fastening it to the mast holding the antenna. A mast-mounted, four-set coupler is also available.

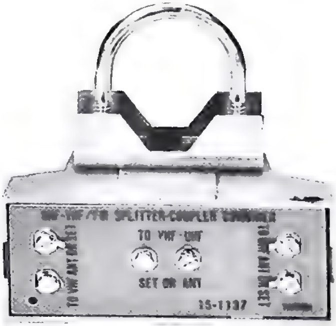


Figure 6-10. A two-set coupler made to mount on the antenna mast.

In small apartment buildings, up to eight sets may be fed with the same antenna. One two-set and two four-set couplers can be connected into a distribution system as shown in Figure 6-11. Since you will be dividing the available power by eight, a good antenna must be put up and installed as high above the roof as practical.

AMPLIFIED SYSTEMS

It is important to keep in mind the more sets that are connected to a lead-in the less signal is available for each set. The loss is actually more than merely dividing the available signal by the number of sets. Couplers are the most efficient way to make multiple-set connections to one antenna, but these devices do have some loss inherent in themselves.

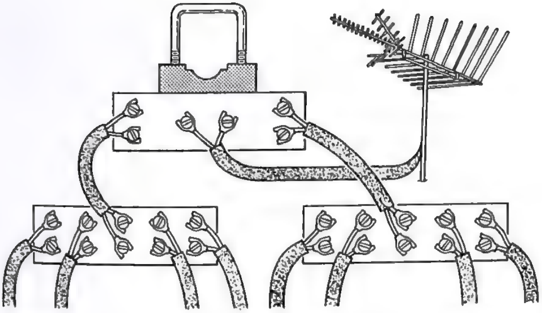


Figure 6-11. A two-set coupler feeding into two four-set couplers.

If you are at a distance from the TV transmitter, or your antenna is not line-of-site in its location, using more than four sets (including FM) may require amplifying the signal to give good results. In large apartment buildings, hotels and motels, a good amplifier is a must for feeding distribution couplers to so many sets. While the amplifiers are powered by the AC lines, they are designed to draw very little current from the line, and may run 24 hours a day at low cost. They are transistorized and may run for years without need for service. This type of amplifier builds up the signal from the TV antenna to override any noise pickup from the lead-in and following distribution cables.

Figure 6-12 shows one such amplifier. The amplifier itself is mounted to the mast right where the connection is made to the TV antenna. The power supply which operates the amplifier is mounted indoors. The lead-in used for the TV signal also carries the power up to the amplifier. A separate cable for this purpose is not needed.

When additional amplification is needed, or for a large number of TV sets, additional amplifiers should be added indoors (Figure 6-13). The output from the mast mounted amplifier feeds one of the indoor amplifiers, which in turn feeds other couplers, four in all in the case of the one illustrated, or other amplifiers like it.

Additional amplifiers are placed at distribution points, then cables are run from them to the TV sets. These amplifiers also have built-in couplers. General practice is to use 75-ohm coaxial cable throughout the system.

Amplified systems are a little beyond the capabilities of the average home mechanic. Their installation is best left to the

Figure 6-12. Signal amplifier. Weatherproof, mast-mounted amplifier at left; power supply at right.

professional organizations, who are better equipped with the necessary tools and knowledge.

It must also be remembered that an amlifier needs a good signal at its input to obtain a good signal at its output. Therefore don't expect an amplifier to make up for a poor antenna or antenna location.

INTERCONNECTING CABLE

Coaxial cable is round and small in diameter. Running the cable from antenna to coupler to sets poses no problems. However, it is expensive, and there is a need to install plugs onto the ends of the cables.

Three hundred-ohm twin lead distribution is less expensive than coaxial cable, and connecting it to couplers and TV sets is a simpler job. It is only necessary to strip a little insulation off the ends and wrap the wires around the screw terminals and tighten down on the screws. Some couplers even have clawlike washers under the screw heads which bite down through the insulation and eliminate the job of stripping. This is not true at the TV set terminals, however.

The only precaution that must be observed in running twin-lead cable around is to avoid coming near large amounts of metal. The cable should not be run near or parallel to electric wires, or water or

Figure 6-13. An indoor TV signal amplifier designed for use with 75-ohm coaxial cable.

gas pipes. There should be a distance of at least four inches from such metal. Shielded cable eliminates this precaution.

Running twin lead around the wall molding is fairly easy except when going from one room to another. Running it around door openings poses a problem and requires a little ingenuity. Special tacks are available to hold the cable in place against the floor molding. Since some 300-ohm cable is clear, there usually is no problem of wall color matching.

The best way to feed cable to the sets is through the wall, and is fairly easy in a one-story home with an attic. The lead-in may be brought into the attic from the antenna either directly through the

roof, or around over the edge of the roof overhang (or via the basement or crawl space). The coupler is fastened to the top of a ceiling joist, or to a roof rafter. Or it may be just laid on top of a ceiling joist without fastening. Nothing will disturb it. The cables to the individual sets are dropped through holes in the wall plate to points in the wall near each set.

The inner walls of nearly all homes have 2 × 4 studs between the plaster boards. No insulation is used in the inner walls and, usually, there is no obstruction to dropping the cable to a point about a foot above the floor line. In some cities the fire codes require firebreaks (fire stops) in walls. These are horizontal pieces of 2 × 4 studs about halfway up the wall. Going through these poses a problem. If your home has a basement or crawl space, coming in from below avoids the firebreak pieces.

The best way to do an in-the-wall installation is at the time the home is being built. Just before the plaster walls go up is an ideal time to get in and run the cable.

Fish the cable through a hole cut into the plaster near the TV set. A better way is to install a TV antenna outlet (Figure 6-14).

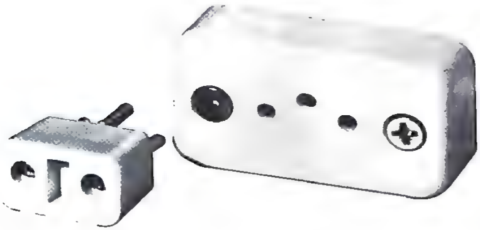


Figure 6-14. A wall socket and matching plug for 300-ohm twin-lead.

More expensive but by far the best way to feed TV sets with connecting cable is to use coaxial cable. It is small and round, and easy to handle. Furthermore, its 75-ohm impedance matches the input of color TV sets. Stripping coaxial cable and installing plug connectors is a bit tedious but not really hard. No soldering is required. The cable consists of an inner conductor and outer shield of braided wires, then an insulating cover over all. Color TV sets in most cases have the coaxial type connectors on them. The plug end of

the cable is plugged into the connector on the TV set, and screwed in place.

The same cable is used from the antenna to the coupler or amplifier, and to individual sets. If the cable is run inside the wall, use wall outlets made with coaxial connectors on them. Make up short cables with plugs to run from the wall outlets to the TV sets. These ready-made leads can be purchased from Radio Shack in 2-, 4-, or 8-foot lengths.

The following chapter gives more about the installation of coaxial connectors.

CHAPTER 7

HOW TO INSTALL A TV ANTENNA

Television antennas are really quite easy to install. They are made so by most manufacturers of TV antennas, and it is especially true of the Archer line, sold exclusively by Radio Shack.

When you buy an antenna, the package you get is much smaller than the antenna. This is because the long elements on the antenna are folded flat against the boom, like the wings of a bird folded against its body. No tools are needed to ready the antenna for installation. The elements are unfolded by hand. Specially designed swivel joints snap the elements into place when they are opened. In fact, it is impossible to refold the elements without damaging them, that's how securely they are held in place. When completely unfolded the antenna appears as shown in Figure 2-2. The elements of the UHF front section are so short they do not need folding, so are fixed in place.

Very complete instructions are supplied for unfolding and installing your antenna. Although the instructions are complete, the language used is compact and terse. Also included with Archer VHF/FM/UHF antennas is a VHF/UHF splitter, the use of which will be covered later.

The larger Archer antennas, models VU-190, VU-160, VU-120, and V-185, are of twin-beam construction. The lower and shorter boom is installed on the mast first, oriented for direction, then the main antenna is snapped onto the smaller boom. The smaller boom becomes a cradle mount assembly. It permits the installer to open out all elements of the antenna, then just snap it into place. It eliminates the cumbersome job of mounting a large and unwieldy antenna directly onto a mast.

ROOF MOUNTING

The most popular place to mount a TV antenna is on the roof of your home. If you are located close to a TV station, and your house is orientated correctly, the antenna may be mounted in the attic. In deep fringe areas even the roof level of the house may not be high enough, and a high tower or mast is needed. But for average metropolitan and suburban distances, the roof of a home usually provides a good height for the antenna.

In addition to the antenna and a mount, you will need a metal mast, either five feet or ten feet long. These are standard TV items in all stores selling TV antennas. They are available at Radio Shack in gold enameled steel. The ends are swagged to permit stacking to greater heights.

There is a large variety of hardware items available for mounting an antenna on the roof. One of the sturdiest is the tripod type of mount shown in Figure 7-1. It is fastened to the peak of the roof or onto a flat roof. Normally a five-foot mast is fastened to the antenna, and the assembly is inserted through the apex of the tripod and through the center brace, for a two-point hold onto the mast. When purchased, the tripod is in a long, but narrow box, as the center brace folds for easier packaging. The bottom feet are adjustable for slanting to match to roof lines. For greater height, a 10-foot mast may be used in this mount.

The roof mount of Figure 7-2 has hinged base plates for adjusting to the roof slant. It is built of heavy-gauge material and will support a TV antenna on a 5-ft mast without additional guying. If a 10-ft mast is used, guy wires should be run from about the middle of the mast to guy screw eyes or hooks in the roof.

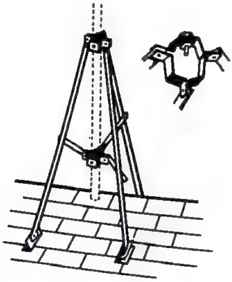


Figure 7-1. Tripod roof mount.

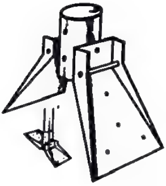


Figure 7-2. Roof peak mount.

Both of the roof mounts just discussed are fastened to the roof with long wood or lag screws. The screws must be long enough to go through the shingles, or tar paper, whichever is used, and into the wood below. If possible, find the location of the roof rafters under the wood sheathing beneath the shingles; long screws make a more secure hold when they also grip the roof rafters. Be sure to daub the areas around the screws with an asbestos-filled roof tar. It is available as a patching tar, in quart cans, from most hardware stores and hardware departments of department stores.

Vent pipes are very secure methods of holding a TV antenna mast. Vent pipes are usually four inches in diameter, and extend through the roof from bathrooms, the laundry area, or kitchen. A two-piece clamp for holding the mast is best. Figure 7-3 shows the bottom of the mast fastened to a vent pipe, using this type of vent clamp.

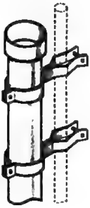


Figure 7-3. A two-piece vent-pipe clamp and mounting.

CHIMNEY MOUNTING

One of the more common methods of mounting a TV antenna is to attach it to the chimney. A number of mounting hardware types are available for this. All use the principle of banding the chimney with stainless steel straps and securing, by means of the bands, the mounting hardware that holds the TV mast.

A popular chimney mount is shown in Figure 7-4. A single strap holds a V-shaped vertical piece to the chimney. A V-shaped part

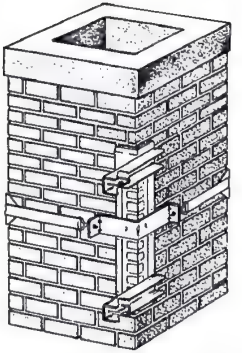


Figure 7-4. A husky, single strap chimney mount.

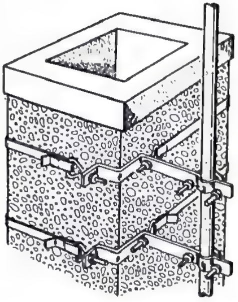


Figure 7-5. A Z-type chimney mount.

against the chimney corner is .05 inch steel. This is fastened to an embossed horizontal section of 12-gauge steel. U-bolts in the horizontal sections hold the TV mast. Figure 7-5 shows the popular Z-mount, the separate parts of which are in the photo of Figure 7-6. A set of two-Z-mounts is required to hold a TV mast.

Both of the mounts above use eye-bolts with one side flat to hold the stainless-steel straps. Nuts on the threaded parts of the bolts draw the straps up tight around the chimney.

The ratchet chimney mount of Figure 7-7 also uses straps around the chimney, but it employs a different method of tightening the straps. A ratchet system, detailed in Figure 7-8, pulls up tight on the strap when turned by a wrench. The idea is a clever one, and some may think this is an easier method of tightening the straps. The nut method of tightening is a little slower but is just as secure when done.

If the chimney is brick, and it appears that some of the mortar has loosened from aging, it would be best to have it tuck-pointed before installing a chimney mount. A poor mortar condition can be made worse from the wind whip on a TV antenna when mounted to the chimney.

WALL MOUNTING

If it is desired to mount the TV antenna in a place that makes it the least conspicuous, it should be mounted as far to the rear of the house as possible. Mounting it to the back wall of the house, with a mast that

Figure 7-6. Separate parts of Z-type chimney mount kit.

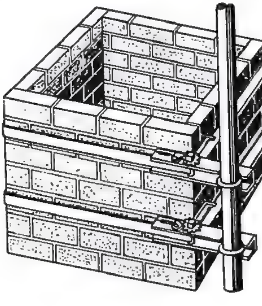


Figure 7-7. A ratchet chimney mount.

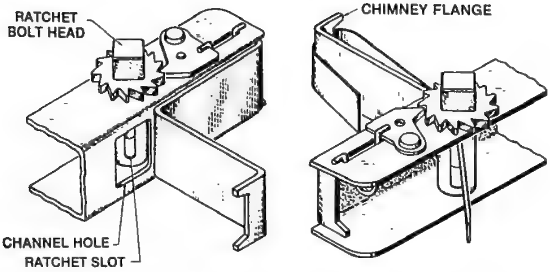


Figure 7-8. Details of a ratchet tightening system.

places the antenna above the roof line, does this. There are several wall mounts available, most of them based on the use of brackets with a V or modified U-shape to them.

Wall mounts are available for clearing roof overhangs from 3 inches to 12 inches.

Figure 7-9 shows a wall mount. The metal is 3/16 inch thick aluminum. The two brackets are mounted one above the other to give two-point suspension to the mast. The brackets hold the mast out six inches from the wall.

Heavy-duty wood lag screws are all that are needed for mounting the brackets to the side of a house using wood sheathing. Try to find at least one of the vertical wall studs, and use screws long enough to reach the stud. The next stud would normally be 16 inches away, too far for the other end of the bracket to reach. With most homes built of brick or stucco, wood screws must give way to lag screws. For brick homes, it is easier to go into the mortar between the brick. For either mortar or stucco, a hole must be drilled or pounded out and a wood or lead insert placed in the hole. The lag screw is placed into the insert, which expands as the screw is tightened. Holes can be made with a

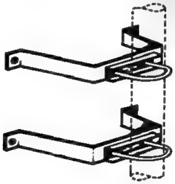


Figure 7-9. A 6-inch wall mount.

carbide-tipped drill bit, or a star drill and sledge hammer. Stucco is concrete about one inch thick. The brackets should be spaced apart about 20% of the length of the mast used.

A sidewall bracket that avoids the need for going into brick or stucco is the one shown in Figure 7-10. This type is wood-screwed to the facia at the end of the house with a peaked roof. The lower element is 48 inches long, to reach across.

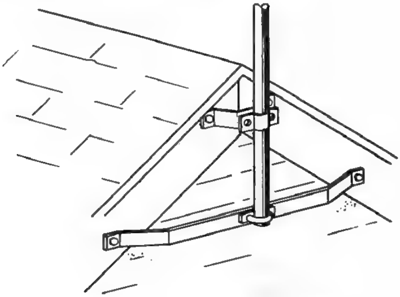


Figure 7-10. Wall mount to fit facia at end of roof peak.

Mounting to the side of the house has one special advantage in lightning protection. A ground wire can be run straight down to a rod in the ground, providing a short and straight run for best protection. Figure 7-11 shows the use of a length of gas or water pipe for a mast, run all the way down to the ground level. Here it is connected to a ground rod with a length of solid copper wire.

MAST MOUNTING

Where greater height than can be provided with a standard five- or ten-foot mast is required, telescoping masts in 19-, 27.5-, and 36-foot lengths are available. Telescoping means the mast is supplied in several sections, each with a smaller diameter, so each fits inside the other. The mast sections are steel, galvanized protected, and with a coating of zinc. In spite of its steel construction, the total weight of the 36-foot mast is only 30 lbs.

Because of the greater height of masts, they must be guyed. Guying rings are supplied with the masts, for attaching the guy wires.

Chapter 5 on fringe area antennas covers the raising of masts.

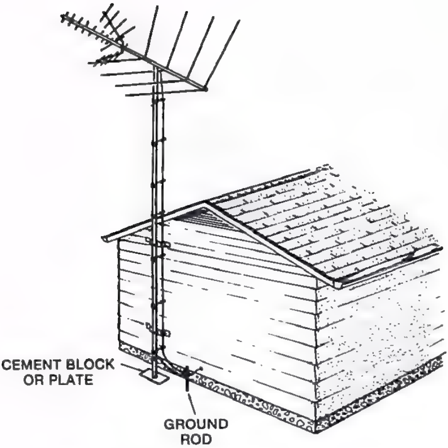
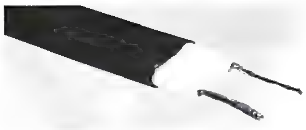


Figure 7-11. Grounding the antenna mast.

RUNNING THE LEAD-IN

The two principal types of lead-in were discussed in previous chapters. As a review, the two types are shown in Figure 7-12. The round, black cable (Figure 7-12B) is coaxial 75-ohm cable. The flat-looking wire (Figure 7-12A) is 300-ohm twin lead. The coaxial cable features the shielding of one lead with an outer lead of braided wire. This and the fact that it is round makes it easier to run from the antenna to the TV set; it is not affected by nearby wires or noise-producing equipment. The insulation between the inner and outer (braided shield) conductors is made of polyfoam, one of the best dielectrics there is.

Among the 300-ohm twin-lead wire, there are three in popular use. The cheapest is the flat brown or clear-plastic insulated type using 22 or 24 gauge wire. This is usable for indoors where weather cannot affect it. The second type is an economy foam insulated type using 22 gauge wire, but also not recommended for outdoor use. The lowest loss type, as shown in Figure 7-12A, uses an abundance of white-foam insulation entirely covered with a dense polyethylene jacket. The foam and large 20-gauge wire contribute to its low-loss characteristics.



(A) Twin-lead.

(B) Coaxial cable.

Figure 7-12. Lead-in cable.

A formerly popular shielded 300-ohm twin-lead has given way to low-loss 75-ohm coax which is much easier to install and lower in cost.

Because TV antennas are designed for 300-ohm lead-in, and the coaxial cable has a characteristic impedance of 75 ohms, a transformer must be used to change from one impedance to the other.

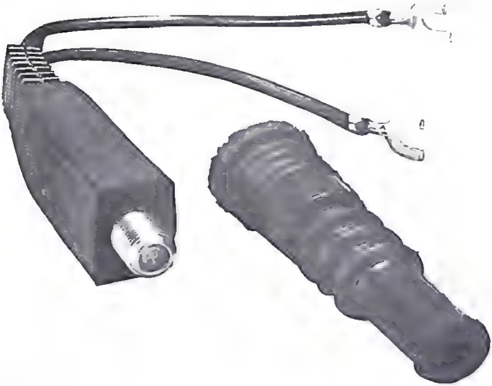


Figure 7-13. The 300-ohm to 75-ohm transformer is supplied with a rubber boot for outdoor use.

The same type transformer can be used to go from 300 to 75 ohms at the antenna and from 75 to 300 ohms at the TV set because transformers are bidirectional. A typical transformer with its rubber boot for covering the coax connector during outdoor use is shown in Figure 7-13. Most modern TV sets come with a 75-ohm input so a transformer is not needed at the input to these sets.

A typical antenna transformer installation is shown in Figure 7-14. Notice the clip which physically secures the transformer to the rectangular boom. This relieves the strain from the wires connecting to the antenna. The rubber boot is shown to the right of the coax connector where it would be before it is pushed up into place. The coax cable must also be secured against the pull of its own weight. Provide some extra cable as slack right at the connector. Remember, wire shrinks in cold weather. If the coax can be looped two or three times around the boom without being near the element feeds, this will provide good strain relief. Don't rely on electrical tape. It will come loose and allow the weight of the cable to pull the connection apart. Use several strong wire ties along the boom and mast.

Another type of transformer uses the words, splitter, combiner, coupler in various combinations. Transformers are reversible in use, therefore the interchangeable names. They may be used to combine or split.

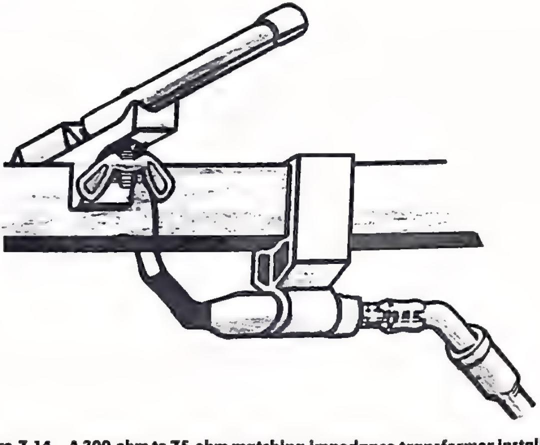


Figure 7-14. A 300-ohm to 75-ohm matching impedance transformer installed at the antenna.

There are two special cases when these are used. When two antennas are installed, one for VHF and one for UHF, their leads can be combined into one lead-in with a combiner (Figure 6-10). The antennas fasten to the outside screw terminals, and the down lead to the center terminals. If a 75-ohm coaxial is to be used as the down lead, a 300-ohm to 72-ohm transformer (Figure 7-13) must be used. At the set, the transformer shown in Figure 7-15 is used to separate the signals from the single coaxial cable lead-in to separate VHF and UHF TV set inputs. Also provided is a set of terminals for FM use. Many TV sets have separate UHF and VHF input terminals.

Figure 7-15. Transformer splitter with 75-ohm coaxial cable input.

Figure 7-16. Indoor splitter for use with 300-ohm line input.

Figure 7-16 shows a splitter for indoor use and where 300-ohm lead-in is used from a single combined UHF/VHF antenna. This one is for use at the TV set for separating signals to VHF and UHF TV set inputs, plus FM.

Figure 7-17 shows installed coax cable plugs. The rubber boot is used for outwork only. No soldering is necessary, and the only tools needed are a sharp knife or razor blade, wire cutters, and a crimping tool, see Figure 7-18. The crimping tool is a cheap life-long investment so don't attempt to do without it. You can not make proper connector installations without it.

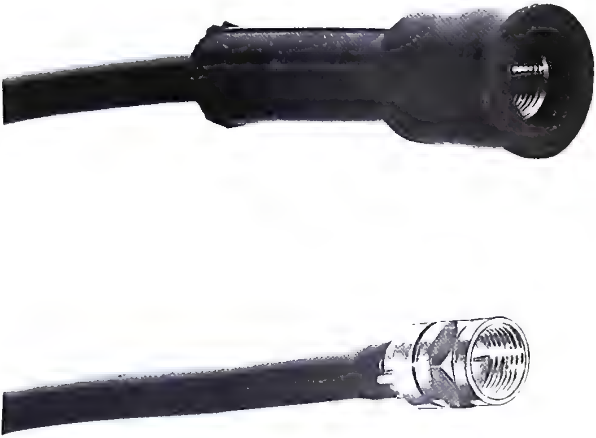


Figure 7-17. Closeup view of coaxial plugs.

Instructions are included with the tool and connectors, but additional points are worth mentioning. Be careful not to nick wires when cutting insulation. Cut only part way through and then tear it the rest of the way. A nicked wire will surely cause you trouble sooner or later. The center conductor should extend about ⅛″ beyond the plug. Center insulation should end at about the inside shoulder of the plug. Fold back the outer shield to cover the cable jacket to the back edge of the crimp ring. This increases shield conduction to the plug and makes removal by pulling almost impossible as the folded-back shield has increased diameter over the rest of the cable under the crimped ring. When bending back the RG-6/U shield and wires

Figure 7-18. Coax connector crimping tool.

carefully tear the foil back to the jacket in 3 or 4 places so that the plug can be installed under the foil without bunching it up.

At least two types of coax cable are popular for TV, RG-59/U and RG-6/U. The RG-6/U is lower in loss and more completely shielded so it is preferred in most installations.

On 300-ohm twin lead, some of the insulation is stripped away from the two wires, exposing about ¾ inch of wires. Twist the wires in the direction in which they are normally twisted in the cable, and bend a hook on both of them. Or, for a more professional job, use crimp connectors.

Both types of lead-in must be supported every few feet to prevent their being whipped by the wind, and, in the case of the 300-ohm twin lead, to keep it away from metals. In addition, the 300-ohm lead must be twisted about five turns every yard. This gives equal capacity effect exposure to any metals that may be nearby, and maintains a balanced condition in the two wires.

STANDOFFS

Different standoffs are used for fastening to different types of structures. The photographs that follow show them. However, the black circular part of the insulators are all the same and are designed to take any kind of cable. They are slotted on one side, and they turn in the metal part that encircles and holds them. The cables are attached by turning the insulator to where the slot is in line with the open part of the metal, and the cable is forced into the center through the slot. After the cable is in, the insulator is turned so the slot is opposite the metal opening. This prevents the cable from coming out of the insulator. However, the slot in the insulator is too narrow to insert heavy cable such as coaxial and shielded 300-ohm twin lead while bound by the metal ring. For heavy cable, remove the insulator by pressing it out, then insert the cable into the insulator, and reinstall it into the ring of the metal holder.

The standoffs in Figure 7-19 are for mast mounting. The strap on the standoff is of stainless steel and one end of the strap is fastened to

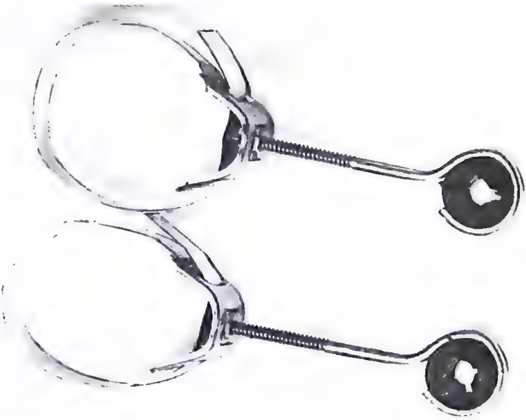


Figure 7-19. Standoff with straps to fasten to masts or poles.

the base of the standoff. The strap is placed around the mast and the free end of the strap is threaded through slots in the base of the standoff. Tightening down on the screws tightens the strap against the mast. Another mast type standoff is shown in Figure 7-20. The hooked part is spring steel and merely snaps onto the mast.

Figure 7-20. Snap-on standoffs are spring steel.

The standoffs in Figure 7-21 are for fastening to wood. A pilot hole should first be drilled into the wood, to make inserting and tightening easier. This practice is good for any wood screw. The standoffs shown in Figure 7-22 are also for wood. They are pounded into the wood like a nail. Note the reverse bend at the top for taking the hammer blows. A crimp on the shank a short distance from the point is used as a depth gauge.

Figure 7-23 shows mortar-type nails as part of the standoff. Like all "hot" nails, they have blunt ends and square shanks. They are easily driven into the mortar between bricks and will also go through concrete, with extra care. But they are primarily intended for fastening into mortar. Use a short-handled sledge hammer and drive them firmly but carefully. The mortar gives way and compacts around the shank for a firm hold.

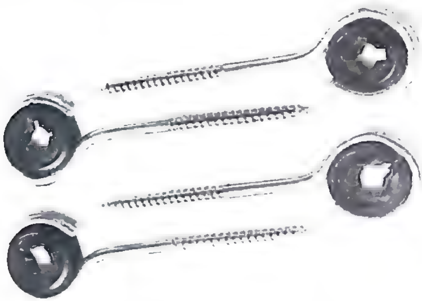


Figure 7-21. Standoff insulators using wood screws.

RUNNING LEAD-IN INDOORS

If the lead-in cannot be brought through the attic and down an inner wall, as shown in the photo of Figure 7-24, the next best thing is to go through the outside wall of the house. This is done by means of a "wall tube," as illustrated in Figure 7-25. This feed-through type of device is all plastic, takes any kind of lead-in, and will fit walls up to 13 inches thick. It includes a rubber grommet for the outside flange, which makes the fit weatherproof.

If the outside wall is brick, select a point at a corner of the bricks and pound a hole through the mortar with a star drill or use an electric drill and a masonry bit. If your home is frame and veneer brick (one thickness of brick), determine where a stud in the wall is by

Figure 7-22. Nail-in standoff insulators for wood.

means of a magnetic device to identify plaster-holding nails in the studs. These magnetic detectors are inexpensive and may be purchased at any hardware outlet. When going through the mortar between the brick, select a point that won't strike a stud inside. An all-brick home will have two or more thicknesses of brick, and ¾ inch furring strips between the brick and plaster walls. A masonry bit will go through the furring strip without trouble.

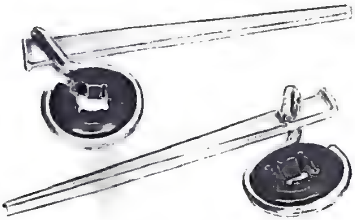


Figure 7-23. Nail-in type standoff for driving into mortar.

Figure 7-24. Coaxial cable entering an attic.

Figure 7-25. Plastic wall tube.

The inside end of the wall tube is made to accommodate the wall socket illustrated in Figure 6-14. Thread the 300-ohm twin lead through the wall tube, fasten it to the terminals of the socket, and fasten the socket to the wall tube. No soldering is required.

A mating plug, supplied with the socket, is then connected to a 300-ohm twin lead long enough to reach the TV set. The plug, also, requires no soldering. If the TV set is not near the socket, you may find it necessary to run twin lead along the molding to the location of the TV set. Special tacks are available to do this, and the installation is quite inconspicuous.

If the lead-in can be brought through the attic and down inside a wall, the installation can be much more professional looking. There is more work involved, however. The work has to do with dropping the cable down inside the wall.

The inside walls of homes are usually made of 2 × 4 studding with plaster board fastened to both sides. Across the top of the studs are one or two thicknesses of 2 × 4 called a plate. On inspection you will

see electrical conduit, or unpiped electrical cable, going through places in the plate that are exposed in the attic. If you are using coaxial cable, or shielded 300-ohm line, you can thread your cable through the same cuts in the plate as the other services, and there is usually enough extra room to do this. For unshielded 300-ohm line you must drill a new hole and keep the line away from any other cables or metallic objects.

Some city codes require home construction to include firebreaks in the walls. These are horizontal pieces of 2 × 4 set in about halfway down the wall. If these are present in your walls, you have a problem. The only way to go through these firebreak pieces is to drop a weighted string down the hole in the plate and estimate the distance down for the firebreak piece. Then, chop some plaster away inside the room at the point where the firebreak is, notch the wood to allow the cable to go around it, and replaster and repaint the wall.

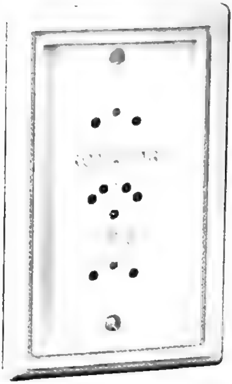
Homes with basements or crawl spaces under them can use the method described above, but working up from the space beneath, through the sill on which the studs rest. The sill is similar in construction to the plate mentioned. Where firebreaks are used in walls, working from a crawl space or basement beneath avoids the problem, as it is only necessary to go about a foot above the molding.

The lead-in may be brought through a wall by cutting a small hole just large enough to accommodate the cable. Estimate the entrance to be as near to your TV set as possible. A preferable method is to install an electrical box and use a socket wall plate. Electrical boxes are available for support by the plaster itself, as well as by nailing to studs.

If you are planning on building, or are in the process of building a new home, the time to put in TV cables is when the house is fully framed, but before the plaster walls have been installed. The work of running cable in the wall is very easy at that time.

WALL MOUNTING SOCKETS

A neat indoor lead-in installation is the end result when cables are run in the wall and terminated in a wall mounting socket. The finished look is like that of an AC outlet of your house wiring system. Figure 7-26 shows several plates available. Some fit the standard electrical outlet boxes, as mentioned above. Others are made for surface mounting onto the wall, and no box is needed behind them. Some are made to accommodate a matching plug, for use with one 300-ohm twin line. Another has two sets of terminal holes for taking two plugs, for use either when two separate antennas and lines are used, one for VHF and one for UHF, or for a single line with a splitter mounted behind the plate. Some plates have terminal combinations for



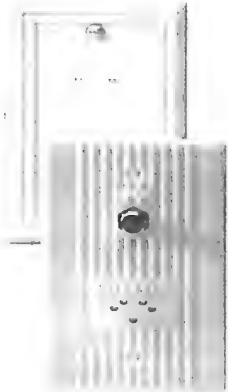
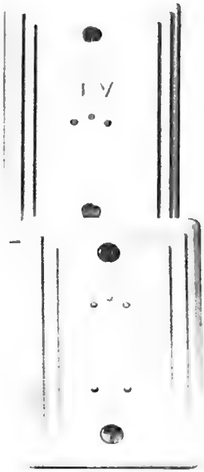


Figure 7-26. Different types of wall plates.



connecting a TV set and a multicable line to a rotor. Matching plugs are available for both. There is also shown a plate that is used with coaxial cable. The type of plug shown in Figure 7-17 screws into this receptacle.

CHAPTER 8

INDOOR TV ANTENNAS

It is a long road from the days of the simple rabbit ear antenna for indoor use, to today's multiple-tuned indoor antenna. Time was when the only TV stations on the air were in Channels 2 to 13, the VHF section of TV channels. And before the days of color TV, the simple rabbit ear shown in Figure 8-1 with its telescoping elements did a pretty good job in locations where outdoor antennas were impossible. Sliding the elements in and out tuned the antenna to the channels in use. Today these are probably used more for FM than TV reception.

DESIGN FOR TODAY'S TV

The evolution in the design of indoor antennas for TV follows the evolution of the increased service offered by TV. When UHF channels came into use, the simple rabbit ears were not adequate. The elements were too long to resonate at the much higher channel frequencies. The rabbit ears were maintained for the VHF section of the band, but elements were added for UHF. Figure 8-2 illustrates one of the simplest of these. The large hairpin shaped element in the center was made tunable by a front knob.

Figure 8-3 shows another indoor antenna for TV. It looks similar to those described above, but has improvements over them. The VHF elements and UHF loops are mounted on a rotating turntable which revolves without turning the entire base. It has a phasing switch to help reduce "ghosts" on the TV screen, plus a switch for selecting optimum results for VHF, FM, or UHF.

Figure 8-4 has a rotating UHF double loop section, and four-section VHF rods. The rotating UHF section permits orientat-

Figure 8-1. Budget VHF Antenna.

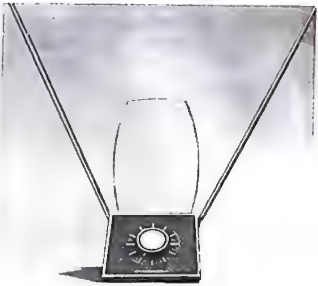


Figure 8-2. Standard UHF/VHF Antenna.

ing the direction for reducing reflections which can cause "ghosting." An added phasing switch allows for better tuning and impedance matching.

THE FINEST INDOOR TV ANTENNA

The best of indoor TV antennas is shown in Figure 3-1. Flexibility of controls results in an ability to adjust for optimum reception when

Figure 8-3. Indoor antenna with a rotating turntable.

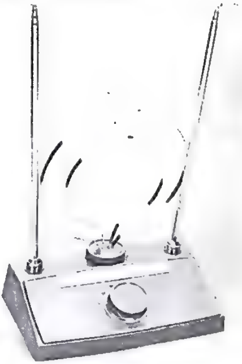


Figure 8-4. Indoor antenna with rotating UHF section.

the use of an indoor antenna becomes the only option. The antenna elements can be turned separately from the base by one knob. Another knob controls a 12-position switch for phasing against reflections in the VHF range.

Having purchased an indoor antenna it is wise to do some experimenting for best results. Experiment with locations in the room. The top of the TV set might seem to be the most convenient place for the antenna, but it is not necessarily the best place. An outdoor antenna has high forward directivity and reduces the possibility of "ghosts" or secondary images. An indoor antenna does not have this quality. Ghosts may be introduced by the return bounce of a secondary path signal from metallic objects in the room. If you encounter ghosts in the picture, move the antenna to another location. Try another, and still another. Find the spot that gives you the fewest ghosts, and the best hold to color pictures.

FM INDOOR ANTENNAS

Like TV, the best reception on an FM tuner or receiver is from an outdoor antenna. Next best is from a two-set coupler connected to a TV antenna, where the coupler feeds the TV set and the FM tuner.

The frequency range of the FM band is 88 to 108 MHz. Being only 20 MHz wide, it does not compare with the broad frequency spectrum of TV. For this reason many FM tuners are supplied with an indoor dipole made of 300-ohm twin line, like the one described in the chapter on FM antennas. While they work quite well they still cannot cover the full 20-MHz frequency width with equal response across the entire band. Nor can they be turned for best pickup if FM stations are in different directions, which is generally the case. The FM indoor antenna shown in Figure 8-5, overcomes the two shortcomings mentioned above. The telescoping elements and tuned coil in the center provide precise tuning to the frequency to be received. In addition, the antenna can be turned on its base for best directivity.

As in the case of the color-TV reception, a stereo signal requires the reception of a much stronger signal for the multiplex control carrier to give good stereo separation. A tunable indoor antenna, such as this one, can give good stereo reception, short of an outdoor antenna.

For those who want to make their own indoor FM antenna, the sketch of Figure 8-6 shows the details. A piece of 300-ohm twin lead is all you need. It is also obtainable ready-made from Radio Shack. This antenna can be tacked behind the hi-fi cabinet, but results are better if it can be installed up higher, such as along the picture molding near

Figure 8-5. FM Stereo Antenna.

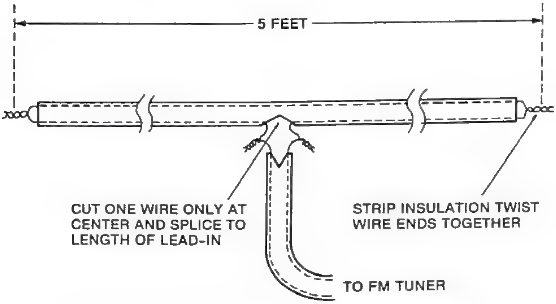


Figure 8-6. An FM antenna you can make from 300-ohm twin-lead.

the ceiling. Its position should be broadside to the path or direction of the principal FM station you want to receive.

CHAPTER 9

INSTALLING A ROTATOR

There are a number of advantages in using a rotator for a TV antenna. In fringe area reception, where the location may be between two cities with TV service, the advantage of being able to turn the TV antenna in the direction of either city is an obvious one. In such fringe area locations, no antenna installation should be contemplated without including a rotator.

Even in close-in metropolitan or suburban areas, there may be an advantage to the use of a rotator, depending on circumstances. In some cities not all TV stations are located in the same place. While the practice is for all stations to work together and all place their antennas on a single high point, this practice is not universal. Where this is not the case, the use of a rotator is a necessity, if best reception is desired from all stations.

Whether all TV station antennas are in the same place or not, there is almost always the problem of secondary paths, which results in ghosts in the picture. A highly directional receiving antenna should eliminate or substantially reduce the strength of the secondary path signal. But where this is not possible, a rotator can be the answer. A rotator can orient your antenna just enough in one direction or the other to turn it away from the secondary path signal, yet not lose enough primary path signal strength to affect the reception. The proper use of a rotator may completely eliminate the ghost.

FM station antennas are hardly ever located in one place. If FM reception is as important to you as the reception of TV, include a rotator in your installation if for no other purpose than to turn your TV antenna (it is assumed you are feeding both TV and FM tuner from the same antenna) in the direction of the FM transmitting antenna location. This is important to the best reception of stereo FM.

MANUAL AND AUTOMATIC ROTATORS

There are two basic types of rotator systems, manual and automatic. Each system consists of a rotating mechanism with an electric motor and reduction gears in a weatherproof housing, and a control box and indicator. The mechanism is located on top of the mast, and the antenna is mounted above it. The indicator is located in the house, on or near the TV set. A three-, four-, or five-wire cable connects the two.

On manual rotator systems, the indicator has a lever or switch and a meter marked with compass points instead of numbers. The lever or switch is pressed in one direction or the other and held while watching the meter. When the needle on the meter shows the direction you want, the lever is released. On the Archerotor, a knob on the control box is set to the direction desired and the antenna follows automatically, see Figure 9-1. A moving indicator tells you when the antenna is pointed in the right direction.

The rotator shown in Figure 9-2 uses mechanical braking to hold the mechanism in its stopped position. The mechanism is held in a fixed position to the lower mast with two sets of bolts and serrated clamps. The bearings are fully weatherproof and lubricated for life. The control box contains the control dial and solid-state circuitry for

Figure 9-1. The control for the Archerotor.

Figure 9-2. Archerotor rotator.

handling the control of the motor. The antenna may be turned in either direction but never more than a complete 360° circle. It uses a three-wire control cable.

RUNNING THE CONTROL CABLE

The control cable may be dressed close to the mast and tied to it at intervals down its length. No special precautions are required to keep this cable away from metallic objects (except 300-ohm unshielded twin line). If the antenna cable is coaxial or if the 300-ohm cable is shielded, the control cable may be brought down and into the house along with, and parallel to, the shielded antenna cable. They may be tied together with wire ties if that is convenient.

The unshielded, ribbon-like, 300-ohm twin line must not be run near the control cable, or any other cable or metallic material. This type of antenna lead-in must be brought down the mast using mast-mounted standoff insulators and carried down and into the house as described before.

ORIENTATING FOR DIRECTION

It is obvious that the antenna must point in the direction to which the control knob has been set. This is easy to achieve.

With the control unit wired to the cable, and the antenna and rotor installed, set the control knob to north. Return to the antenna installation and loosen either the bolts to the antenna or the bolts holding the rotor to the lower mast. Turn one or the other to point to the north, and retighten all bolts.

CAUTION. The antenna lead-in cable must be given enough slack to allow the antenna to turn through a half-circle (180°) in either direction. The rotator does not turn the antenna continuously, but through a circle of 360° and back again. By securing the antenna lead-in at the half-circle point, only a half-circle slack need be allowed.

With the antenna turned to point south, fasten the standoff insulators on the south side of the mast. Allow a loop of cable above the highest mounted standoff, leaving a generous amount of slack. As the antenna rotates to the north in either direction, the slack will be taken up, although it should not pull tight, Figure 9-3 shows how to do this.

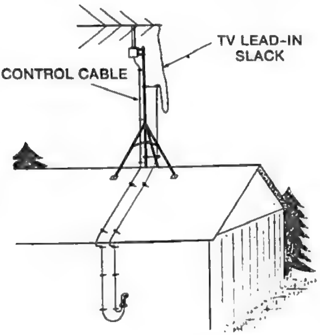


Figure 9-3. TV antenna installation with rotator.

CHAPTER 10

TV INTERFERENCE AND WHAT TO DO ABOUT IT

Interference as it is defined here is that which occurs outside of your TV set. It does not include rolling pictures or other out-of-sync problems in your set or at the TV transmitter. But there are forms of interference which can spoil a good picture and frequently something can be done about it.

There are many sources of radio waves which fall partly in the frequency of a TV channel, and ride into your set along with the TV signals. Most originate from sources very close by and frequently can be treated with some form of filter connected to the TV lead-in. Some cannot be cured.

SNOW

This type of interference actually looks like it is snowing on the screen when you are watching a program. The weaker the TV signal the heavier the snow appears. To overcome this you must build up the signal strength. This is done by using a better antenna, mounted outdoors as high as possible. The antenna requirements for fringe area reception were covered in Chapter 5.

GHOSTS

Another problem that must be included in the definition of interference from external sources is "ghosting." This and its solution were covered before as it, also, is something you can control. The solution is the selection of a highly directive antenna and its proper orientation. See Chapter 3 for more details.

INTERFERENCE FILTERS

The kinds of interference mentioned above cannot be reduced by adding gadgets or special devices to your TV system. There are forms of interference that can be reduced by the use of a device called a filter. A filter is a tuned circuit of capacitors and inductors designed to pass radio frequencies within the TV bands and reject all those below or above it. In technical parlance these are called bandpass filters. Other types pass frequencies above a certain frequency and reject all others below that value. They are called highpass filters. And then there is the simple capacitor which, depending on its value, acts like a short circuit to high radio frequencies, while not affecting very low frequencies. Filters are used to reduce or eliminate the type of interference described below, except fluttering.

SPARKING

A most annoying type of interference is that resulting from sparking in electrical equipment (Figure 10-1). Such sparking can come from the brushes of universal type motors, such as those used for circular hand saws, electric drills, sewing machine motors, etc. It will look like a series of white dots in horizontal lines across the TV screen.

Interference of this type described as sparking may enter the TV set in one or both of two ways. It may be picked up by the AC line feeding power to the set, or it may be picked up by the antenna, whichever is closest to the source of interference. A filter may be

Figure 10-1. Interference caused by sparking.

used at either or both points, that will bypass all or most of the spark pickup and keep it from getting into the TV set. Figure 10-2 is an antenna-type filter. For use, the antenna lead-in is disconnected from the back of the TV set, and the two leads of the filter are connected to the TV terminals. The lead-in is connected to the pair of screw terminals on the filter. Within the filter is a bandpass circuit that blocks out all radio frequencies above and below the TV frequencies, but allows TV frequencies to pass through. Since interference sparking is at radio frequencies, those that fall within the TV frequencies will get through. However, quite a bit of the spark interference will be blocked, with a resulting decrease in interference.

The best way to reduce sparking interference is at the source. There are bypass capacitors which can be connected across motor brushes and other sparking devices to short-circuit the sparking. But this requires knowing the equipment and what value capacitor to use, and is best left to a professional to do.

Figure 10-2. An interference filter which connects between the lead-in and the TV set.

THE HERRINGBONE PATTERN

Figure 10-3 shows a typical herringbone pattern across the TV screen. It is caused by other transmitter services, notably the Citizens band (CB), and to a lesser degree amateur radio operators (hams) who are using their radio transmitting equipment.

There are over 10 million CBers in the country and one or more are undoubtedly near you; that is, within a block or two. Their frequency of operation is between 27 and 28 MHz. CB interference is caused by harmonics of the transmitting frequency falling into a TV channel. A harmonic is a multiple of the basic frequency.

Figure 10-3. Herringbone pattern caused by CB transmitter radiation.

Nothing can be done at the TV set to keep harmonic interference out. The best you can do, if you can determine who the offender is, is to request (but you cannot demand) that he observe silent hours during your favorite program, or suggest he add a lowpass filter to his equipment. This filter will reduce the harmonics from his transmitter.

When a CB or other transmitter is very close to you, even the fundamental frequency can cause interference by what is called swamping. In this case the very closeness can produce enough power to get through your set. There are two filters you can add into your antenna lead-in to reduce and sometimes eliminate this. Figure 10-4 shows a filter which connects directly to the terminals of your TV set. A more effective filter is shown in Figure 10-5. This one connects in series with your antenna lead-in. That is, you connect the antenna lead-in to the connector at one end of the filter, and the short lead from the other end of the filter to your set.

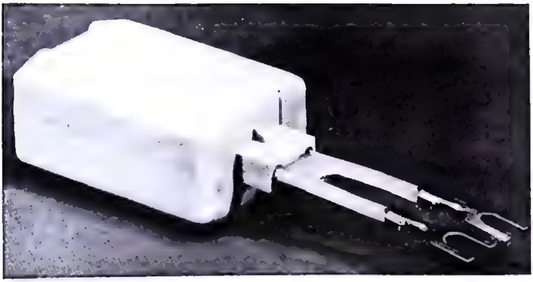


Figure 10-4. A trap-type filter for connecting across the antenna terminals.

Amateur radio stations can also cause the same kind of interference mentioned above. There are only about 250,000 licensed amateur stations, but they generally run higher power than the CBers.

Amateur stations are less of a problem for two reasons. For one, nearly all amateurs use a low-pass filter at the output of their transmitter to keep harmonic radiation down. And, number two, you will usually find them very cooperative in working with you to do something about any interfering problem. Again, remember, they are licensed by the Federal Government to operate a transmitter and demands to stay off the air will get you nowhere. A friendly request for assistance will get you a friendly response.

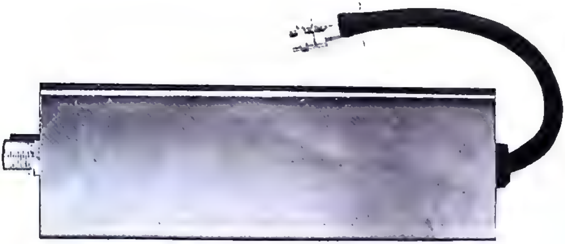


Figure 10-5. A deluxe high-pass filter.

PICTURE FLUTTER

Airplanes flying overhead, especially to or from the direction from which the signal is being received, frequently cause the picture to flutter. That is, the picture will get brighter and dimmer in cycles of about three to fifteen times a second. This is the result of signal reflections from the metal of the airplane. It is a secondary path signal similar to that mentioned in an earlier chapter. Because of the movement of the airplane the secondary path signal will arrive in phase and out of phase with the direct signal. Thus the signals sometimes add and sometimes subtract from the level of the original path signal. The effect is especially noticeable when indoor antennas are used.

To avoid or reduce flutter the same high directivity of antenna mentioned earlier to reduce ghosts is required. This narrows the beam of signal acceptance thus increasing the strength of the original path signal, and reduces the strength of the secondary path signal from the airplane.

CHAPTER 11

CB ANTENNAS

All antennas must meet certain basic requirements, but transmitting antennas are more critical as to the matching of impedance between the feed line and the antenna. This match is indicated by the amount of Voltage Standing-Wave Ratio (VSWR and often shortened to SWR) on the transmission line. Ideally the VSWR should be unity (one-to-one), indicating a perfect impedance match. Just about any length of wire can be used for *receiving* AM, FM, TV, CB, etc., but the impedance of an incorrect length of antenna could cause a CB transmitter to malfunction and not deliver its power to the antenna. The narrow frequency band of the 40 CB channels covers only 0.44 MHz (26.965 to 27.405 MHz) compared with the 20 MHz of the FM band, 34 MHz of the low VHF TV band, and 42 MHz of the high VHF TV band. For this reason, simple-looking antennas can be designed to provide an acceptable impedance match between antenna and feed line over the entire CB band.

It is conventional for CB to use vertically-polarized radio waves. This dictates vertically oriented elements, resulting in omnidirectional radiation patterns when single-element whip antennas are used. This is ideal for communicating to all directions. Recall from Chapter 4 that a horizontally polarized antenna as used for FM becomes more complicated to obtain an omnidirectional pattern.

To obtain maximum radiation in the horizontal direction, you would think that the higher (longer) the vertical antenna is made, the greater the horizontal radiated signal strength, but this is not the case. Assuming a perfect ground, as the vertical whip is increased in height, signal does increase in strength until the electrical height of about ⅝ wave length is reached, and then signal strength starts to decrease drastically in the horizontal plane and increase vertically above the antenna.

To complicate matters, we usually don't have a "perfect ground" so we use three or four ground radials at the base of the whip and elevate the entire system as high as possible (or legal) above undesirable ground and other objects, see Figure 11-1. These ground radials perform three very important functions: operate in conjunction with the whip (antenna) section to obtain resonance in the CB band, electrically decouple the mast from the antenna so that the mast and whip don't act together as an antenna higher than ⅝ wavelength (which would cause most of the RF energy to be directed vertically over the antenna), and thirdly, help to provide a feedpoint impedance as close to 50 ohms as possible.

ANTENNA LENGTHS AND IMPEDANCE MATCHING

A signal wavelength in free space is equal to the velocity of propagation in meters-per-second (300 million/second) divided by the frequency in cycles-per-second or hertz (27.2 MHz for the center of the CB band). The CB wavelength is therefore about 11 meters. From this we can determine the expected lengths for antennas having the typical ¼ wave (or less) to ⅝ wave. A quarter-wave antenna is about 2.75 meters (9 feet), a half-wave about 5.5 meters (18 feet), and a ⅝ wave about 6.9 meters (22.6 feet). These lengths are for a theoretical antenna of negligible wire diameter, but indicates to us that to obtain a reasonable antenna height some engineering must be done.

Only two antenna heights within the range of ⅝ wavelength will give us a pure resistive feed-point impedance without some form of loading coil or transformer, ¼ wave and ½ wave. And, of these two, only the ¼ wave presents an impedance near the 50 ohms which is common for coaxial cable. Therefore, only ¼-wave antennas can be made without loading coils or matching transformers for direct feeding with 50-ohm coax, and then only with proper ground-plane construction.

The theoretical feed-point impedance of a quarter-wave antenna with horizontal ground-plane elements is about 36 ohms; and that of a half-wave dipole in free space is about 73 ohms. Design engineers are therefore able to obtain a 50-ohm feed impedance by proper choice of the ground radial angle somewhere between horizontal and vertical (downward) on quarter-wave antennas, see Figure 11-1. Other factors which affect the feed-point impedance are the length of all antenna elements and the presence of a matching or loading coil. The feedpoint is always at the junction of the vertical radiator and the ground-plane elements. The vertical radiator is connected to the coax cable center conductor and the ground elements to both the mast and cable shield. This allows the mast and cable shield to be well grounded to earth for better lightning protection.

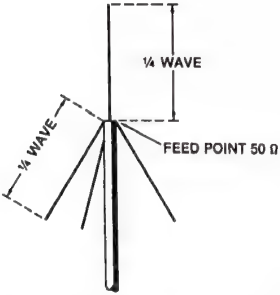


Figure 11-1. Basic quarter-wave ground-plane antenna.

All other antenna lengths require the use of a top capacity hat, a center loading coil, or a base loading coil or transformer to obtain a feed impedance of 50 ohms and resonance of the antenna system. Some whips are constructed with what might be called a distributed loading coil. Wire is wound around a fiberglass core the entire length of the whip and then completely covered with a thick layer of fiberglass to provide added strength and insulation. This type construction gives better durability, improved radiation efficiency, and some protection should the antenna accidently come into contact with a power line.

Coaxial cable is always used for the feedline, and the same comments apply for CB antenna work as for TV. That is, use as low a loss cable as you can afford when more than a few feet are needed or you will lose a great amount of the already-low transmitter power (4 watts maximum) in the cable. At the frequencies used for CB, around 27 MHz, the size of the cable is more important than the type of insulation. For example, small RG-58/U cable typically has a loss about twice that of the larger RG-8U. The loss difference between either cable having the same center conductor size but foam insulation in place of solid insulation is negligible. This, of course, differs from that at the upper VHF and UHF TV frequencies where the insulation has a big factor. An RG-58/U coax is typically used for runs of 25 feet or less, such as in mobile installations, and RG-8/U is used for all longer runs.

QUARTER-WAVE GROUND-PLANE ANTENNA

This type antenna is identified by a simple vertical whip section about 9 feet high and having three or four ground radials of about the same length as illustrated in Figure 11-1. Direct impedance matching to the 50-ohm coaxial cable is very good when ground radials are

sloped downward at an appropriate angle, usually about 45°. This eliminates the need for any kind of impedance matching device, which tends to restrict bandwith and inject signal loss. The whip and ground radials are simply connected to an SO-239 type connector which receives the standard PL-259 type plug used on 50-ohm coaxial cable. Cable may be purchased with these plugs already installed, simplifying installation. Sloped radials are also effective for maintaining maximum radiation in the horizontal plane, as opposed to horizontal radiators which tilt the radiation upward toward the sky.

HALF-WAVE GROUND-PLANE ANTENNA

A full-size half-wave ground-plane antenna may be identified by both its height of about 18 feet and the bulky matching network at its base. The matching network may take on various physical forms, but its function is always that of changing the impedance at the base of the half-wave whip from a few thousand ohms to the 50 ohms required for coaxial cable.

A half-wave antenna doesn't require ground radials to complete its resonant operation as does a quarter-wave antenna, but something is still needed to complete the feed impedance connection for the coax, and decouple the mast from operating as an extension of the antenna. Therefore, ground radials or a quarter-wave decoupling sleeve is still required to keep the entire mast and coaxial cable from acting as the antenna. A properly-constructed half-wave ground-plane antenna is capable of producing a gain of up to 1.67 dB over a properly-constructed full-sized quarter-wave one. This is a power increase of about 1.5 times.

The desire to produce an antenna with higher gain than the simple quarter-wave type has resulted in a shortened form of this antenna. Various methods have been used such as center loading coils, base loading coils, distributed loading coils, and top capacity hats. Figure 11-2 shows a shortened whip that uses a top capacity hat. Antennas which are shortened severely do not provide significant gain over a well-designed full-size quarter-wave antenna. This is due to both the decreased radiating-element length and matching network losses.

⅝-WAVE AND 0.64-WAVE ANTENNAS

The highest gain is possible with a properly-designed antenna in the ⅝ to 0.64 wavelength, but as with the ½-wave type, any attempt to shorten the antenna or skimp on the decoupling of RF currents from the mast and coax by reducing or eliminating ground radials or decoupling sleeves defeats the purpose of going to these larger antennas. A ⅝-wave antenna having double ¼-wave decoupling

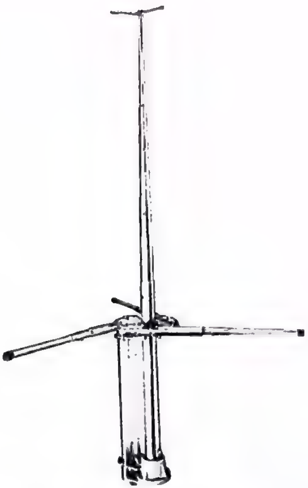


Figure 11-2. A shortened whip utilizing top-hat loading.

sleeves is capable of the highest gain in this type antenna, but this type has not gained popularity in CB. A popular marine radio antenna using this construction has a 3 dB (2 times power) gain over a typical ½-wave ground-plane antenna.

COAXIAL ANTENNA

A decoupling sleeve as just mentioned is illustrated in Figure 11-3. Construction and characteristics are varied enough from the ground-plane antenna shown in Figure 11-1 that a different name is applied to this type antenna, the coaxial antenna. The name comes from the fact that the lower part of the antenna is made up of a sleeve which is 3 to 10 times larger in diameter than the coaxial cable and is coaxial to it. This sleeve is connected to the cable shield at its top, where the center conductor also connects to the top whip, and is then insulated from everything over its entire length. All three radial requirements are efficiently provided by this type construction. The quarter-wave whip and quarter-wave sleeve work together as an effective half-wave resonant vertical antenna (even though this is commonly called a quarter-wave coaxial antenna due to the whip length length). The coaxial cable outer shield and inside surface of the sleeve form a decoupling

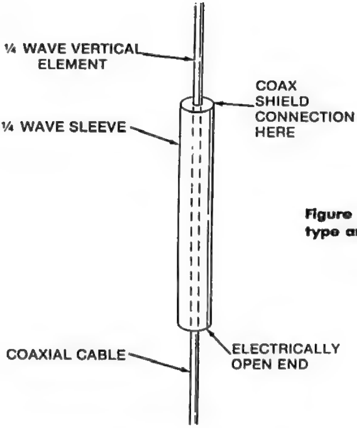


Figure 11-3. A quarter-wave coaxial-type antenna uses a sleeve to replace the radials.

stub which makes the RF see a very high impedance at the open end of the sleeve. This effectively decouples the coaxial cable and mast from acting as part of the antenna. The thickness (diameter) of the whip and sleeve tends to lower the feed impedance of this half-wave system from the theoretical 73 ohms of the infinitely-thin free-space half-wave reference antenna to the 50-ohm impedance of the coaxial cable. The use of any poor matching system is therefore eliminated.

With the advent of the law requiring base station omnidirectional antennas to tolerate a fall against a power line (see LAWS AFFECTING CB ANTENNAS at the end of this chapter), this coaxial type antenna using fiberglass construction will probably become the most common type omnidirectional base station antenna. Figure 11-4 illustrates a base station coaxial antenna. The quarter-wave whip and quarter-wave sleeve give a total height of approximately 16 feet. This full-size antenna complies with the newly enacted law.

INDOOR CB ANTENNA

There is a CB antenna designed for indoor use. It is made a half-wave in electrical length by the use of a fiberglass rod with antenna wire helically wound around it. The top section adjusts from 7½ feet to 8½ feet. It is supplied with seven feet of coaxial cable connected, and ending with a PL 259 plug. All you need do is set it up

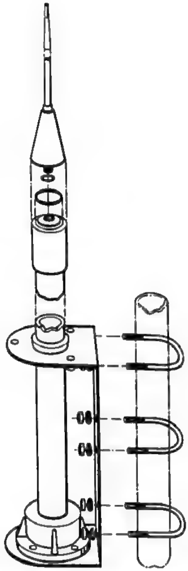


Figure 11-4. Omnidirectional base station coaxial antenna.

in the corner of the room and plug it into the CB transceiver. Adjust the top section for best performance.

One must not expect the same results from this antenna as from an antenna mounted outdoors at a greater height, and with full-sized dimensions. But lacking that possibility, such as in an apartment, this antenna will give surprisingly good performance.

BEAM ANTENNA

Talk to any amateur radio man and he will tell you, when physical dimensions permit, his most effective antenna is a beam antenna. This is a type of construction similar to that described for TV antennas earlier in this book, but with a higher efficiency due to the much narrower bandwidth over which they operate. The increased forward gain and the higher front-to-back ratio results in an effective power gain many times that of a standard half-wave antenna.

The 3-element beam for CB is like an amateur radio beam except for having its elements in a vertical position instead of horizontal. The

center element is the one the coaxial line is connected to. The long element to one side is the reflector, and the short element on the other side is a director.

The maximum forward gain, the designation for power increase in the forward direction, is almost 9 dB, making a 4-watt output as good as a 32-watt output from a half-wave only antenna. The front-to-back ratio refers to the difference between the front of the antenna to the back of the antenna in output or receiving sensitivity. This ratio is approximately 25 dB, which is a mathematical ratio of 300 to 1. Theoretically, a station at a given distance behind you would have to have 300 times the power of a station the same distance in front of you to be equal in received loudness.

But, for effective use of a beam it must be capable of being turned to the direction of the station with which you are communicating. This calls for the use of a rotator, and both antenna and rotor installed on a mast. The same rotator used for TV may be used for CB. See Chapter 9.

CUBICAL QUAD ANTENNAS

Another very directional beam antenna which is popular in amateur radio and adapted to CB is the cubical quad antenna. This is generally used in a modified version where the driven element is a vertical whip (or whips), but the director(s) and reflector are loops of wire near one wavelength in circumference. This type antenna can be made using light but strong fiberglass poles and small size wire so that the weight of this massive-looking antenna is actually less than many Yagi-type beam antennas. The problem arises when an ice storm causes excessive weight which is too much for the boom or cross members to support. The gain and front-to-back ratio of a three-element quad antenna rivals that of a Yagi-type beam of three or four elements.

MOBILE ANTENNAS

The greatest feature in operating Citizens band is the ability to communicate from a moving vehicle, at a small investment in equipment. Most CB transceivers today use solid-state circuitry, are small, and are easily mounted under the dash of a car. All that is necessary is to mount an antenna and connect it.

Most CB mobile antennas are pretty much alike, differing only in details. The similarity lies in the use of a quarter-wave vertical element, with the car body acting as the other quarter-wave, for a half-wave theoretical antenna. They differ in the method of mounting, in general construction, and in the use of loading coils in cases to reduce the length of the vertical element.

The first consideration in the selection of a mobile antenna is to decide where it is to be mounted on the car. The best place electrically is on top of the car roof. This results in the best omnidirectional pattern because the mass of the car body is evenly distributed under the antenna. The drawback in roof mounting is the total height above the car, which might interfere with underpasses or garage entries. Shown in Figure 11-5 is the Archer "Shorty" roof antenna. It has a coil in the center which adds inductance to the antenna and makes it possible to reduce the physical length while maintaining resonance. This antenna is only 18 inches high. It has a spring at the base to allow the antenna to bend if it hits an obstruction. It requires drilling a ⅜ inch hole in the roof of the car and running the lead-in behind the roof upholstering, like the wiring to the dome light. The antenna snaps into its mount, so it may be quickly removed for entering a garage or for clearing other overhead obstructions. Another roof-mount antenna is shown in Figure 11-6.This antenna is made of fiberglass with wire inside, and includes a coil at the bottom called a base-loading coil, to reduce the length of the whip yet retaining an electrical quarter-wave size. Fiberglass is quite flexible.

Figure 11-5. The "Shorty" roof-mount antenna.

Figure 11-6. A fiberglass roof-mount antenna, with loading coil.

One favorite place to mount a mobile CB antenna is on the trunk lid. Most trunk-mount antennas are designed to be mounted without drilling holes in the metal. The mount clamps around the edge of the lid, or uses a powerful magnet to hold the mount to the metal.

Trunk mount antennas include a coil at the bottom of the antenna element to maintain the quarter-wave length electrically, while permitting the use of a shorter radiating element. Also at the bottom, just below the loading coil, is a steel spring. This permits the antenna to bend if an obstruction is hit.

Figure 11-7 shows a magnetic-mount type of antenna. The powerful magnet at the base holds the antenna in position even at high car speeds. The antenna element is stainless steel.

Figure 11-8 shows a no-hole, trunk-grip antenna. The top and bottom gripping parts are gasketted to avoid marring the car paint. Figure 11-9 is similar to Figure 11-8, but with the whip made of graphite. It is stiffer than fiberglass but more flexible than stainless steel.

Figure 11-7. A magnetic-mount type antenna.

Figure 11-8. A no-hole, trunk-grip antenna.

Figure 11-9. A no-hole mount with a graphite whip.

Figure 11-10. A full-length whip on a spring body mount.

Figure 11-10 is an example of a body-mount antenna. This antenna mounts at the side of a fender cowl or truck body. It is a full 102 inch stainless steel whip. To mount it holes must be drilled. The swivel ball joint permits adjusting the antenna position.

Bumper-mounted antennas eliminate drilling into the car's sheet metal. Furthermore, the full quarter-wave length of whip is possible (Figure 11-11).

CB/FM/AM DISGUISE ANTENNAS

The following three antennas are designed to provide two features. They are made to look like a standard fender-mount antenna for AM radio use, thus reducing the temptation for theft. In addition, they include a specially designed splitter transformer which supplies signals separately to the car radio and to the CB rig.

Figure 11-11. A bumper-mount antenna.

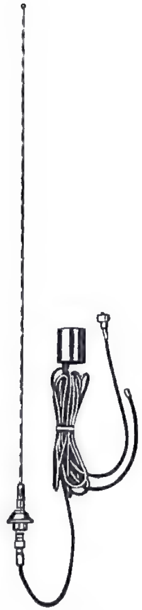


Figure 11-12. A 108-inch whip designed to mount in hole for standard mount AM antenna.

Figure 11-12 has a stainless steel whip and mounts through a standard car antenna mounting hole. A splitter with separate leads and plugs divides the signal between FM/AM and CB use.

CB antennas for long-haul trucks are usually mounted to their West Coast style mirror. The one shown in Figure 11-13 has a special clamp for mirror mounting. It is center-loaded so the whip is shorter than the usual quarter-wave length.

Figure 11-14 shows a dual-antenna system which provides some directivity. With one antenna on each side of the cab, and connected together through a phasing harness, directivity forward and to the rear is emphasized.

Figure 11-13. Single antenna for mounting to truck mirror.

Figure 11-15 shows a gutter-clamp CB antenna. It is intended for temporary installation. The antenna clamps to the metal gutter strip at either front door, and the cable is brought in through the window, to the CB rig.

LAWS AFFECTING CB ANTENNAS

All CB stations are required by law to have on file a current copy of the Federal Communications Commission (FCC) CB rules. These rules are published periodically by the U.S. Government Printing Office, for sale through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for about $4.50. Changes to the CB rules first appear in the Federal Register and other publications, such as this antenna book.

The latest law affects the manufacture of omnidirectional CB base station antennas. This new law was not instituted by the FCC but by the Consumer Product Safety Commission. In an attempt to decrease the accidental deaths from contact with power lines by CB base station whip antennas during their installation or removal, the Com-

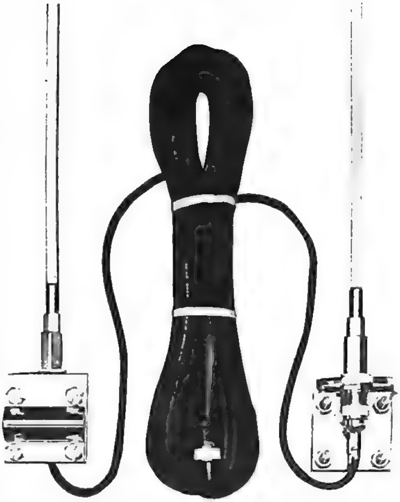


Figure 11-14. Dual truck CB antenna gives directivity.

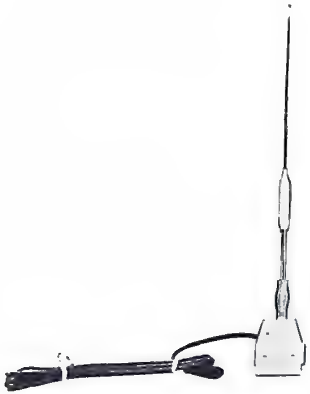


Figure 11-15. A gutter-clamp mount CB antenna.

mission has ruled certain type construction and tests be followed on these antennas. As a CB antenna installer, you will be affected most by the decreased choice of omnidirectional antenna types available and by the increased cost of the antennas which must comply with this new rule. Antennas manufactured or imported before the institution of this rule on February 25, 1983, may still be purchased. All complying antennas will be of heavier and insulated construction, and will be in cartons containing the necessary certificate of compliance. Directional antennas escaped this ruling because of the complexity of trying to make these multi-element antennas relatively safe around a 14,000-volt power line. No law or material construction can give you complete safety around power lines so the best rule might be **STAY CLEAR OF ALL POWER LINES BY A DISTANCE AT LEAST TWICE YOUR ANTENNA HEIGHT.**

A long-standing law which does affect you directly concerns the maximum height allowed for a CB antenna. Rule No. 18 states, in effect: Fixed station antennas may be no more than 20 feet above the highest point of the building or tree on which it is mounted, or no more than 60 feet above the ground. If you live near an airport, you may have to obey additional restrictions. You may contact the FCC for a worksheet to help you figure your maximum height in this situation. Your CB rules give some good illustrations which we need not repeat here.

CHAPTER 12

INSTALLING FIXED-STATION CB ANTENNAS

Class D Citizens band communication takes place in the 27 MHz band. At this comparatively low frequency, radio waves can be radiated in two ways. One is the sky wave. Radio waves are radiated out at an upward angle and are reflected down by the ionosphere. Sky-wave signals can reach out several thousands of miles (Figure 12-1). Communication by the sky wave is illegal to CB equipment users.

The other form is the ground wave, which is radiation almost parallel to the plane of the earth's surface. This is like the radiation of TV signals at the higher frequencies described in earlier chapters of this book. The communication path for the ground wave is almost line-of-sight (Figure 12-2).

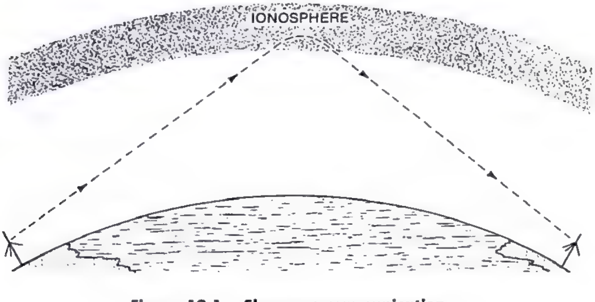


Figure 12-1. Sky-wave communication.

Figure 12-2. Ground-wave communication.

Since communication is limited to ground-wave radiation, it becomes necessary to try to accomplish two conditions. That is, use the highest possible gain antenna, and mount it as high as possible. If communication over short distances meets requirements, it is not necessary to use great heights. But the higher the antenna, the farther out is the horizon, and the greater the distance of communication.

Since Citizens band communication is available to every citizen of the United States, without examination, the FCC felt some limits must be placed on communication range to reduce as much as possible interference between stations. This was in anticipation of millions of stations coming on the air, a forecast that was realized. The limits are to the power of the transmitter (four watts output), and the height of the antenna.

HEIGHT

FCC regulations limit the height of a CB antenna to one or the other of the following: It must not be more than 20 feet above the highest point of the building or tree on which it is mounted. It must not be more than 60 feet above ground. This refers to the top of the antenna. If a 50-foot mast installed at ground level gives you greater overall height than mounting the antenna on your house, you may use the mast.

For a business with offices in a multi-story building even the 20-foot limit offers excellent opportunities for a high antenna, with excellent coverage possibilities.

While the use of a tall building for an antenna offers the advantage of height, there are some offsetting disadvantages that must be considered. All feed lines have some losses, some more than others. If the transmitter is far from the antenna, on the first floor of a 10-story building for example, the losses could be considerable. The most popular type of feedline cable for base stations is type RG-8/U, a heavy-duty coaxial cable, 0.4 inch in diameter. This cable has a loss factor of 1 dB per hundred feet at 30 MHz. Assuming about 200 feet of cable are used to reach from the first floor to the roof of the above example, plus some to reach the antenna set in from the edge of the building and to reach to the transmitter, total loss is 2 dB. This

converts to a 37% power loss. However, the advantage of height overcomes this loss in net coverage. Using the lighter cable, RG-58/U, the loss due to the use of a long cable becomes significant. RG-58/U cable has a rated loss of 3 dB per hundred feet. At 200 feet this converts to about a 75% loss. In other words, only about 25% of the power fed to the cable by the transmitter ever reaches the antenna. Obviously, in this example, investment in the heavier cable is worthwhile.

As a general rule, the heavier coaxial cable is nearly always used for base station installations. The lighter cable is used for mobile installations.

HOME ROOF MOUNTING

CB base station antennas mount to the same type of mast as TV antennas. The U-bolt mounting clamps are the same. Any of the methods of mounting described in Chapter 7 for TV antenna mounting also apply to CB antennas.

Legal height limits may restrict the choice of antenna. Consider the 20-foot limit. A full ¼-wave antenna height of 9 feet would limit you to the use of only 11 feet of mast. A full ½-wave antenna height of 18 feet would only allow you 2 feet of mast. A full ⅝-wave antenna height of 22.6 feet could not be used. Typically what is used in this case is a 5-foot mast and a shortened ½- or ⅝-wave antenna, or a 10-foot mast and a full-sized ¼-wave antenna.

CONNECTING THE FEEDLINE

The best way to buy coaxial cable is in precut lengths with connectors already installed. These are packaged in 2-, 5-, 20-, 50-, and 100-foot lengths. This cable includes two PL-259 type plugs already installed on the ends.

Connect the cable plug to the antenna as shown in the closeup view of Figure 12-3. Bring it straight down and tie it to the mast every 2 or 3 feet apart with wire ties. Run it into the house about the same as you would TV cable, except that the standoff insulators made for TV cables are too small to take RG-8/U. It does not matter if the cable is near metal, because it has a shield under the outer cover. Any method of securing it to the house or building will do as long as the cable is not punctured in the process.

One of the best methods of bringing this cable into the house is through a hole in the wall opposite the operating position. A plumbing elbow whose inside diameter is at least twice the outside diameter of the cable should be installed with the outside opening

Figure 12-3. Plug on end of cable screws into connector on all base station antennas.

facing downward (Figure 12-4). This makes a waterproof entrance. Caulk the outside openings, and plaster the inside around the coax to maintain the insulation of the building.

If the 50-foot cable is a bit longer than needed, just coil up the remainder under the operating table. There is not enough loss in the use of a small extra amount to warrant cutting it to exact length and installing a plug. There is only a 12% loss in the entire length of 50 feet of RG-8/U cable, so a few extra feet over will represent only a small percentage of the 12%.

The other end of the cable with its plug installed is merely screwed onto the output terminal of the transceiver or whatever CB equipment is used. Later you will be shown how to connect PL-259 plugs to cables cut to length.

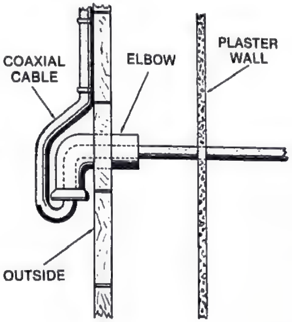


Figure 12-4. The best way to bring the antenna cable into the house.

GROUNDING FOR PROTECTION

Unlike a TV antenna, a CB antenna has a vertical element that reaches up fairly high into the sky. This vertical element may be insulated from the mounting plate and the mast. It connects to the center conductor of the cable feeding the antenna. Protective grounding is considered in detail in Chapter 15; it should be read thoroughly.

INSTALLING COAXIAL CABLE CONNECTORS

When bulk coaxial cable is used, the ends must be dressed, and PL-259 plugs installed onto the ends. This takes some dexterity and some experience in soldering, although there are some solderless types of plugs, but these require special crimping tools.

Figure 12-5 shows how the ends of the cable are dressed. The inner conductor is soldered to the center pin of the plug. Since the pin protrudes out slightly in front of the shell, the inner conductor of the cable is made slightly longer than the rest of the cable parts. The braided outer conductor is soldered to the shell of the plug. The length of each cut on the cable is easily determined by laying it against the plug.

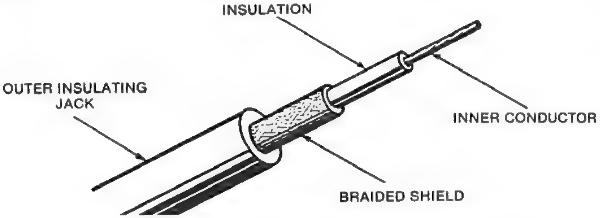
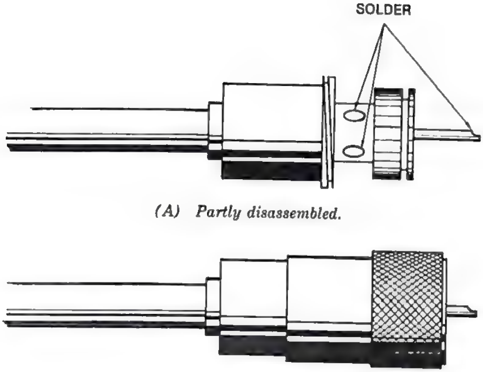


Figure 12-5. Preparing coaxial cable for soldering to a plug.

Unscrew the outer shell from the plug, and slide the shell onto the cable, well below the end. Screw the plug onto the cable and solder the center conductor to the pin of the plug. Solder the braided shield to the neck of the plug through two of the holes in the neck. This is more easily done by pretinning the shielded braid before inserting the cable. It will take a hot soldering iron to solder through the holes of the plug. This is shown in Figure 12-6A. Sketch B of this figure shows the completed assembly, after the outer screw-on shell is slid up and screwed back into place. Note: Don't forget to slide the shell onto the coax before soldering the plug.



(A) Partly disassembled.

(B) Assembled.

Figure 12-6. Coaxial cable connector.

CHAPTER 13

INSTALLING THE MOBILE ANTENNA

There is a wide selection of mobile antennas for CB use. The basic kinds were described in Chapter 11. Each one comes with complete instructions on how to mount them on a car. Considering that one is working at ground level, it is not difficult to install a mobile CB antenna.

Unlike the earlier days of CB, it is no longer necessary to drill holes in the body of the car to mount a CB antenna. It may be preferable to drill a hole to mount a "disguise" type antenna mentioned earlier, but most antenna installations are done without drilling holes. The magnetically-mounted car-top antenna is probably the most convenient.

TRUNK LID MOUNT

Two no-hole methods are used, the magnetic mount, and the edge clamp. The magnetic mount is illustrated in Figure 11-17. The base of the antenna is a powerful ceramic magnet which adheres to the metal body of the trunk. This antenna could also be used to mount on the roof as easily, except for the feed of the cable. The magnetic-mount antenna is merely placed in position on the trunk lid, near the upper edge. The feed cable is routed over the trunk lid edge and down into the trunk. For secutity the antenna is easily removed and dropped into the trunk through the opening at the back when the lid is up. Thus, when your car is parked with no one in it, no antenna is visible.

The clamp-mount antenna has a U-like clamp at the back edge which fits over the edge of the trunk lid. It is clamped in place with screws that are underneath. It is fed by coaxial cable in the same way as the magnetic mount. While the entire mount may be unscrewed

and the antenna placed in the trunk when you are not using the car, it is more convenient to merely remove the vertical antenna element from the mount and place it in the trunk, leaving the mount in place on the trunk lid. By leaving the mount in place you may be advertising the fact there may be a transceiver in the car, but at least the antenna won't be stolen.

GUTTER-MOUNT ANTENNA

The antenna merely clamps to the rolled-up edge of the rain gutter. The accompanying illustrations cover the installation of the Radio Shack gutter-mount antenna. It is only 18 inches high, but has a loading coil that makes it an electrical ¼ wave long. It has attached to it a length of RG-58/U cable which has a PL-259 plug attached on the end. It comes ready to be immediately plugged into the CB transceiver in the car.

Because of its small size and ease of installation and removal, the gutter-mount antenna is intended for temporary use. Although its short length reduces the risk of hitting low overpasses and other solid obstructions, a spring at the bottom will give when obstructions, such as low overhanging tree branches, are hit, with no damage to the antenna.

Even though this resonates in the CB band, an antenna as short as this must not be expected to give the results of one whose physical length is the full ¼ wave for resonating. For a temporary antenna, however, results are good.

Figure 13-1 shows the details of the gutter-mount antenna. Figure 13-2 is a closeup of the clamp which holds to the inside of the gutter. For mounting, the clamp is first loosened, then fitted over the gutter and tightened. When held firmly, there is a tendency for the antenna to bend towards the car body. An adjusting screw centered between the clamping screws is turned in until its rubber tip presses against the car body to push the antenna into an upright position.

Figure 13-3 shows the antenna being mounted to the gutter of a car. The cable is fed in through the window, and the plug screwed into the antenna socket of the CB transceiver.

BUMPER-MOUNT ANTENNA

Because the bumper of a car is at a low level, an antenna mounted to it can be a full physical ¼-wavelength without the use of loading coils. While excellent results are obtained, there is some directional effect due to the mass of the car body. The ideal installation, electrically, would be on the top of the car body, in the center of the

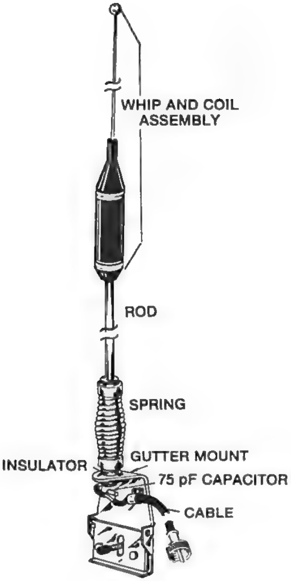


Figure 13-1. Construction details of the gutter-mount antenna.

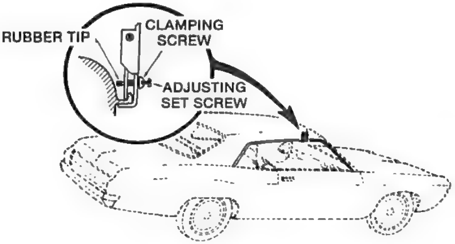


Figure 13-2. Details of the gutter clamp.

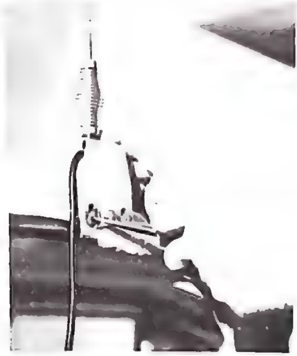


Figure 13-3. Antenna being fastened to a gutter rail.

roof. But an antenna physically a quarter-wave in length would extend nine feet above the roof, which makes it rather impractical.

CONNECTING THE CABLE

The feed cable can be run to the transceiver in either of two methods. One is to run it under the car chassis, into the motor compartment, and back through the firewall to the transceiver. Wire ties should be used to fasten the cable to nonmoving parts of the chassis underneath. The other method is to go into the trunk, through the wall between the trunk and the back seat, and under the edge of the carpet to the transceiver. This is the method used most, and is rather easy to do. The cable is less than ¼-inch thick and easily fits along the edge under the carpeting.

TUNING THE ANTENNA

The most effective radiation and reception with a transceiver is when the antenna is resonant and the impedance matches that of the coax. The 40 CB channels cover a total of .44 MHz in width, and commercially purchased antennas will usually cover that width with good efficiency.

Antenna length is related to its resonant frequency. For precise resonance an antenna can be cut to an exact length. Some antennas are made for easy adjustment. Others may need some trimming by cutting off some length.

When the impedance of an antenna matches the impedance of the connecting cable at a specific frequency it is said to be resonant to

that frequency and matched to that cable. So resonance is checked by measuring the impedance match, and this is done with an instrument called a SWR bridge. SWR means standing wave ratio. It is not necessary to know the theory of standing wave ratio. Suffice it to say the lower the ratio the closer the impedance match and the closer the resonance.

The photo of Figure 13-4 shows a SWR tester. It requires no external power to operate it. It works from the power output of the transceiver. It is one of several standing-wave ratio (SWR) instruments; the more expensive ones measure the SWR of high-powered transmitters. Adjusting for minimum SWR, adjusts for resonance and impedance match between transmitter and antenna. It may be connected at the transceiver and left in the feed line permanently for observation of antenna performance.

Connect the SWR tester between the feed line and the transceiver. Have the channel selector on a channel near the center of the CB band. Turn the transceiver on and lock it in transmit position. Set the switch of the SWR tester on "FWD" and adjust the right-hand knob for full scale setting of the meter needle. Set the switch to "REF" and read the meter. If it reads between 1:1 and 1:1.2 you are close enough to resonance for excellent performance and no adjustment need be made to the antenna. If the SWR reading is higher than 1.2 some antenna length adjustment is necessary or the ground connection is not good enough. Always check for poor ground connections before changing the antenna.

The gutter-mount antenna described above adjusts typically. Loosen the knurled lock nut at the bottom of the coil and slide the coil up or down on the lower section of the vertical portion of the rod. With each adjustment of length, make a new measurement of SWR. Each time the SWR is measured reset to full scale in the FWD mode.

Figure 13-4. Micronta field strength-SWR tester.

The bumper-mounted antenna is a full 108 inches long with the spring in place (the spring adds 6 inches to the length). At its full length, it is nearly resonant to 26 MHz. To test this antenna, set up the SWR bridge (SWR tester) as for the gutter-mounted antenna. The SWR will probably be above 1:2. Using heavy-duty wire cutters, or a hacksaw, cut one-half inch off the top and make a new measurement. If still not close enough, repeat the cutting operation and remeasure. It may take as many as 10 of these cuts to reach resonance, but it is advisable to take it a little at a time to prevent going past the point of best SWR.

This same instrument has another feature. It is also a field strength meter. By plugging about a 20-inch piece of stiff wire into the "FS ANT" jack in the center, the instrument will pick up some of the RF sent out by the antenna and the meter needle will move up. Maximum output from the antenna usually means the antenna is resonant and the ground plane (car body etc.) losses are low.

While the above applies as well to base station antennas, their location is such that adjustments may be difficult to make. Adjustments are generally made only if the SWR over the entire CB range exceeds the maximum specified for the transceiver.

USEFUL ACCESSORIES

A number of accessories are available to make installation more flexible, or for transferring an antenna from one car to another, or to a truck.

A hold-down clip (Figure 13-5) can be fastened to the gutter near the front door of the car. When you need to lower a long antenna to enter your garage, just bend it and clip it to this device.

Figure 13-6 is a no-hole trunk mount for use if you already have the whip or vertical antenna.

Figure 13-5. A hold-down clip.

Figure 13-7 illustrates a bracket that mounts to truck mirrors and accepts standard antennas with ⅜-24 thread up to 4 feet long. A later model of this bracket also mounts to horizontal luggage-rack bars.

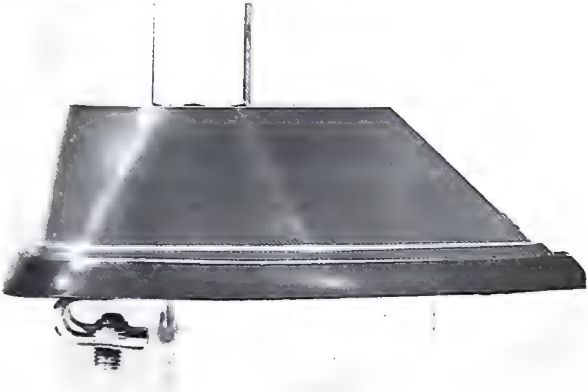


Figure 13-6. A no-hole truck mount.

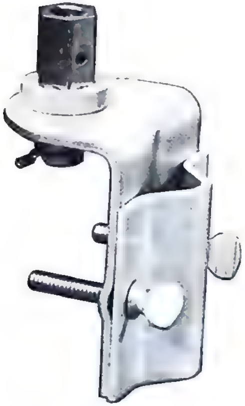


Figure 13-7. A mounting bracket that attaches to a truck mirror.

NOISE FILTERS

Because the frequencies of CB operation are high, noise developed in the engine can produce a hash-like sound in the CB receiver. A number of filters are made to reduce or eliminate this noise.

Figure 13-8 shows a heavy-duty inductance-capacitor filter to be connected into the plus and negative leads to your transceiver. It filters out noises coming through the supply line (12 V). Figure 13-9 shows an ignition noise suppressor. It plugs into the center of the distributor, and the original wire into it. It is a resistor type. Figure 13-10 shows an alternate noise suppressor. It mounts on the alternator to filter the 12 V output wire. Figure 13-11 shows a high-value capacitor filter. Connect in-line at strategic places if other filters are not effective enough. This may also be used in fixed-station applications when wired in series with the AC line to motors or other noise-producing devices.

Figure 13-8. Inductance-capacitance filter used in 12-volt supply line to transceiver.

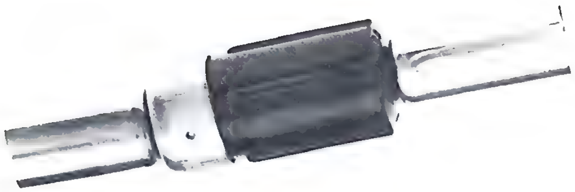


Figure 13-9. Resistive-type ignition noise suppressor.

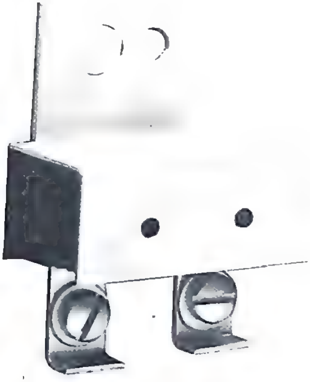


Figure 13-10. Alternator noise suppressor.

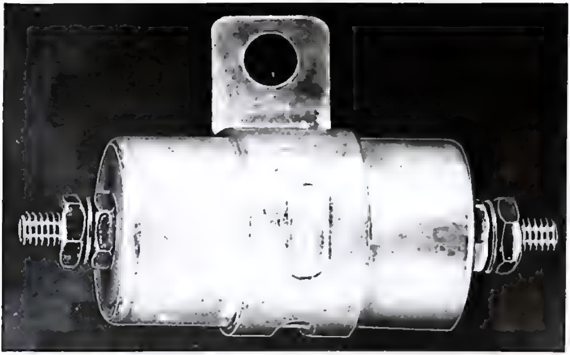


Figure 13-11. High-capacity bypass capacitor for filtering high-frequency noise.

CHAPTER 14

ANTENNAS FOR SHORTWAVE LISTENERS

Those of you who own a good shortwave receiver and like to listen to foreign broadcasts as well as Voice of America, amateur radio transmissions and other services on the shortwave band will increase the fun of listening in with a good antenna. There is nothing particularly special about a good antenna for this purpose. It needs to be reasonably long, and up as high as possible.

THE INVERTED "L" UNIVERSAL ANTENNA

The most common type of antenna, and one which performs very well, is the inverted "L," which looks like just what the name implies, an L upside down. Figure 14-1 shows the basic inverted L.

While the inverted L antenna consists of a stretch of wire which is the antenna proper and a lead-in connecting the antenna to the receiver, in performance the entire antenna and feeder are picking up signals. There is a type of antenna in which the feed line does not pick up signals, and this will be discussed a little later. The wire used need not be an insulated, or covered, type. However, construction must be such as to insulate the antenna from anything metallic or subject to dampness through the use of insulators. The wire itself may be bare. Stranded copper antenna wire is excellent for use and is easy to bend and flexible in the wind. The antenna wire and the installation must be sturdy enough to withstand high winds, the weight of sleet and ice, and the extra pull when contracted by cold.

Every electrical circuit requires two wires, to carry the current to the load and back again. The inverted L antenna requires a ground for the return path. The ground post on the back of the receiver should be connected to one of several grounds—to a cold water pipe (never a gas pipe) in the house, to a metal radiator in the house, or to

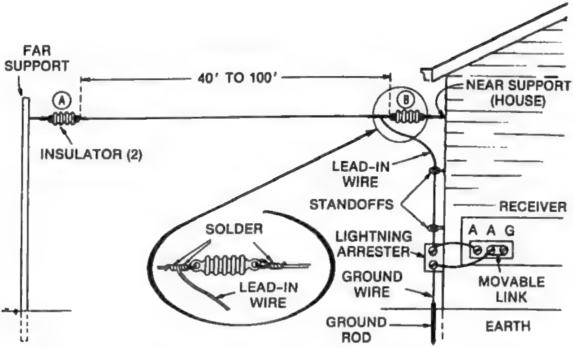


Figure 14-1. Basic inverted L antenna and details of installation.

a metal rod outside driven into the ground about 8 to 10 feet.

The ground post in the receiver is also connected internally, in the receiver, to the AC lines through a capacitor. Very often the use of an external ground, one of the three mentioned above, gives no improvement. The connection to the post in the ground has another function—lightning protection—when a lightning protector is connected to it.

PACKAGED COMPLETE ANTENNAS

You may purchase the antenna parts separately or buy a complete package. An inexpensive one is shown in Figure 14-2. It consists of 75 feet of stranded antenna wire, 25 feet of lead-in wire, two antenna-end insulators, two knob nail insulators for the lead in, and an insulated, flat copper lead-in strap for installing under the window sash. For adding a ground and lightning protection, add a short piece of heavy copper or aluminum wire, a grounding clamp, a ground rod (Figure 14-3) and a lightning arrester.

THE HALF-WAVE FOLDED-DIPOLE ANTENNA

The antennas just described are called random-length antennas. They are good for pickup of all frequencies in the shortwave range, although they do peak at the odd multiples of a quarter-wave in length. If your interest is only one shortwave band, an antenna cut to

Figure 14-2. A complete kit of parts for an inverted L antenna.

precise length, such as a half-wave twin-lead type folded-dipole will give better results.

The sketch of Figure 14-4 shows an antenna made entirely of 300-ohm twin-lead cable. The top section is cut to resonate to the desired frequency band. The formula for antenna resonance is:

$$\frac{468}{f(\mathrm{MHz})} = \text{length (feet).}$$

For example, to cover the foreign broadcast 19-meter band, first convert meters to frequency by dividing into 300:

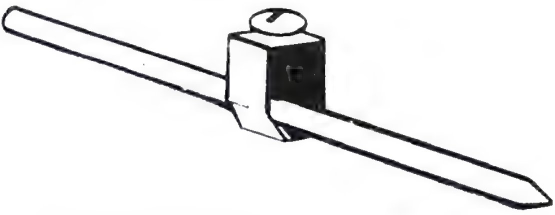


Figure 14-3. Ground rod and clamp for lightning protection.

$$\frac{300}{19} = 15.79 \text{ MHz}$$

By inserting the frequency into the resonance formula the length comes out to be 29.64 feet. A length of 29 feet 8 inches is used.

The feeder and the antenna are made from the same kind of cable. When you buy cable figure on the length of the antenna, plus the length of the feeder to come straight down from the antenna for about one-half the length of the antenna, then into the receiver.

Cut off a 29 foot 8 inch length of cable.Strip about one-half inch of insulation from both ends of this piece. At each end solder the two conductors together. At the very center cut one of the conductors. Pull the two cut ends away from the rest for about one inch, and strip the insulation from these ends back about one-half inch. From the remaining length of the 300-ohm cable, strip the wires of insulation at one end, and solder one wire to each wire exposed from the center of the antenna section.

Only the 30 feet of antenna up in the air picks up radio waves. This is good as the antenna should be above any noise developing sources. The lead-in does not pick up radio waves. The two wires of the feed line are out of phase with each other and cancel out any pickup of radio noises. No ground is needed at the receiver, except for protective purposes.

This method may be used to make antennas for any one of the high-frequency shortwave or amateur bands.

SUPPORTING THE ANTENNA

Work for two objectives in putting up an antenna. One is to get it as high as practical. The other is to completely isolate it from any metals or moisture-holding material. The highest point on the house is usually one point of suspension. A high pole, neighbor's house, or tree is the farther point of suspension. Insulation is by means of white, glazed, porcelain-like insulators.

A blownup view of one point of suspension can be seen in Figure 14-1. Suspension at the other end is similar, except that no wire is soldered to the end for a lead-in. A heavy-duty screw eye will hold firmly in wood. In brick or stucco, an expansion anchor plug must be installed before fastening the screw eye. It is easier, and just as good, to find some wood member of brick or stucco homes, such as the facia boards at the top. Be sure to screw into the supporting 2 × 4 rafter holding the facia board, not into the facia wood only. Often the wood used for facia board is redwood, which is not very strong.

A well-painted 2 × 4 or 2 × 6 sunk into the ground about four feet is a good support for the far end. If this support is over 10 feet above the ground, it may need to be guyed, to prevent the antenna wire from pulling it out.

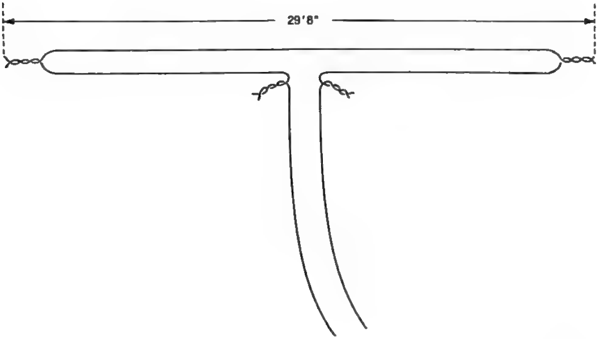


Figure 14-4. A 19-meter folded-dipole antenna.

Select an area clear of trees or other obstructions, to prevent the antenna touching any tree limbs or other objects. If a tree is used for the far end support, pick one with a sturdy trunk to prevent pull on the antenna wire in a wind. If one of the higher limbs is used, a device for allowing for wind sway must be included. This may be in the form of a pulley, as shown in Figure 14-5, or spring loading. Be sure the insulator is far enough out from the tree foliage to prevent interference with the antenna proper. Use a safety line on the weight to keep a falling weight from injuring someone.

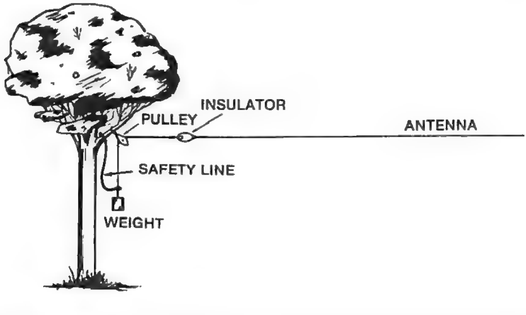


Figure 14-5. Pulley and weight arrangement of an antenna system.

Do not use the utility pole as the far end support of the antenna. If you do, then don't be surprised to find the utility company has cut down your antenna some day.

In the case of a twin-lead antenna, both ends are considered far ends, with the lead-in connected to the center. One end may be fastened to your own house. However, the lead-in must be supported so it comes away from the antenna proper at right angles to it for a distance of about one-half the length of the antenna, if possible. It must not parallel the antenna close by.

BRINGING IN THE LEAD-IN

It is just as important that the lead-in wire be insulated from other metals or damp material as the antenna proper. The lead-in is part of the antenna, in the case of the inverted L-type antenna. After soldering the end to the antenna, bring the lead-in to the point of entry, supported by nail-type insulators or TV-type standoff insulators. This is especially important where the lead-in crosses over a metal gutter. Place the insulators so the lead-in is carried around and over the gutter, with a few inches distance between the two.

Two methods are popularly used to bring the lead-in into the house. One is through the window, and the other is through a wall.

The short strap pictured in Figure 14-2 is made of a flat piece of copper, covered with flexible insulation and with a spring clip at each end. It is well suited to the inverted L antenna and is the simplest way to bring the lead-in into the house. It fits under the window sash. With wooden sashes there is no metal proximity, except for weather stripping. On metal sashes its proximity to the metal alters the electrical length of the antenna to a small extent. In addition there may be some signal loss on a rainy day.

Place the window strap in position on the window sill. Bend the strap to fit the shape of the sill and any weather stripping. Slam the window down on the strap, and the strap should form to the sill and sash.

Cut the outside lead-in to a length to reach the outside clip on the window strap. Skin insulation off the end of the wire and connect it to the clip.

Going through a hole in the wall is better suited to a deluxe antenna installation, such as the one just described with a matched impedance feed line. The method is shown in Figure 14-6. A plastic pipe elbow is used to prevent rain from coming into the hole. The plastic pipe is an acceptable insulator so that proximity to the lead-in is not a factor as it would be if metal pipe were used. Another method would be to use a plastic wall tube shown in Figure 7-25. Be sure to weatherproof all openings in the wall, inside and out.

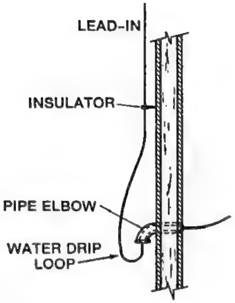


Figure 14-6. A good way of bringing the transmission line into the house.

Make some measurements from each corner of the house to the selected point of entry. Find a spot where there is no wall stud. Wall studs are normally 16 inches apart, center-to-center in most homes. Check the inside of the house at about that spot to make sure there is no AC outlet below the selected area. If there is an AC outlet, avoid the space between those studs as you may run into the conduit carrying the wires or, worse yet, the wire itself in those cities which permit plastic-covered cable without conduit for house wiring. Find another pair of studs to go between.

On a brick or stucco house, a star drill or masonry drill bit will be needed. Working from the outside, start in the mortared corner of the brick and drill out a hole. Chip away at the brick until the hole is large enough to take the lip of the pipe elbow. A wood drill is used for a house with wood slats. A rough cut, round rasp file may be needed to increase the size of the hole in wood.

The pipe elbow will hold to wood with epoxy cement. It will hold to brick or stucco with epoxy, or a latex patching concrete mix.

CONNECTING TO THE RECEIVER

The back of a receiver will have two or three screw terminals for connecting the antenna. Those with two terminals will usually be marked A for antenna, and G or GND for ground. This type of terminal is intended for the random-length, or inverted L-type antenna. A wire connection is made between the window lead-in strap clip, or other method of lead-in entry, to the A terminal. Connect a wire between the ground terminal and a cold water pipe, a metal radiator, or the wire coming in from the ground rod driven into the ground on the outside. That wire may be brought into the house in

the same way as the lead-in. As mentioned once before, the receiver may operate just as well without a ground connection, because an RF ground is made inside the receiver to the AC lines, via the case itself. If the receiver is AC/DC powered, and has no ground terminal, never go inside the case to make a ground connection.

A ground rod driven into dry earth, such as is found in the Southwest, is not a good ground for signal pickup return. However, it is a good ground for lightning protection, as discussed later.

Skin any insulation from the ends of the connecting wire and scrape the copper clean with the blade of a knife or a piece of sandpaper. Twist the end of the wire over the loosened terminal screw post in a clockwise direction (Figure 14-7). This prevents the wire from being squeezed out as the screw is tightened down.

Receivers with three-terminal inputs may be used for a single -wire antenna, or a dual-wire twin lead. These terminals will usually be marked A1, A2, and G or GND. If a single wire antenna is connected, wire a jumper between A2 and G, as shown in Figure 14-8. Connect a ground lead to G or A2. For a balanced wire lead-in, one wire is connected to A1 and the other to A2. With a twin lead, or balanced line lead-in, a ground is not necessary on the G or GND terminal (Figure 14-9).

The inverted-L antenna is also ideal to use when experimenting with a crystal set or other simple receiver. Some of the best memories I have are as a youngster competing with a neighbor on our home-

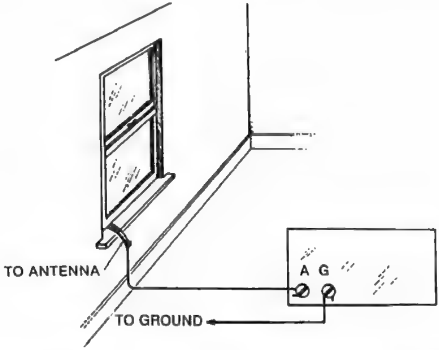


Figure 14-7. Connecting a single-lead antenna to a receiver having a two-terminal antenna block.

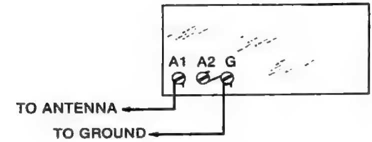


Figure 14-8. Connecting a single-lead antenna to a three-terminal antenna block.

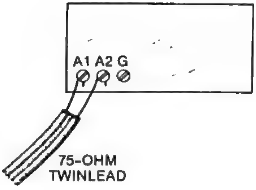


Figure 14-9. Connecting a balanced wire lead-in to a receiver.

built crystal sets. My friend was able to get better results until I learned how to tune the antenna circuit. After this experience, I was hooked on electronics and eventually became a ham and then an electronics engineer.

CHAPTER 15

SAFETY PAYS

If you value life and property forget about putting up an outdoor antenna, whether it is a TV, CB, or shortwave antenna unless you can observe certain precautions.

Nearby power lines on utility poles can be a hazard. A tower must be located so that if it should fall from a high wind it will not fall across electric wires. In addition a tower must avoid the possibility of falling onto someone else's property which could become damaged. Poles and towers must be guyed keeping in mind the strongest possible wind in your area.

A shortwave antenna is long. Don't ever be tempted to run it across power lines, nor fasten one end to the nearby utility pole. Running the wire across power lines is a sure invitation to possible death. The danger is two-fold, getting the wire across the power lines, and the possibility of the wire falling onto the power lines later. Fastening one end to a utility pole includes the possibility of accident while climbing the pole, and a good chance it will be cut loose later by the power company. The poles are the property of the utility company, and they have every right to cut your wire down. Shortwave antennas should be installed at right angles to power lines to reduce interference pickup from the lines.

IMPORTANT SAFETY RULES

When installing antennas for television, shortwave, CB or other receivers the following safety rules should be adhered to strictly.

1. Perform as much antenna assembly as possible on the ground.
2. Observe if there are any overhead power lines nearby. The installation should be a minimum of twice the maximum length of antenna and mast assembly away from power lines. Thus, if

your antenna and mast length is 15 feet long, the closest power line should be at least 30 feet away.

3. Remember that the mast, cable and metal guy wires are all excellent conductors of electricity so keep them away from power lines too.
4. Make sure your family and friends understand the danger of the antenna touching overhead power lines. Tell them never to try to remove any object that has come in contact with a power line.
5. If any part of the antenna system should come in contact with the power line, *call your local power company to remove it. Do not try to remove it yourself.*
6. If after all precautions an accident should occur with the power lines
   (a) Do not grab hold of a person who is in contact with the antenna and power line.
   (b) If you must remove the person in contact, use a *dry* board, stick or a rope to push or pull the antenna away from the victim.
   (c) If the victim has stopped breathing, administer artificial respiration and have someone call for medical help.
7. Do not use a metal ladder when installing the antenna.
8. Do not install the antenna on a windy day.
9. Do not mount the antenna on a tower or mast assembly over 30 feet long. Such an installation should be done by a professional installer.
10. For masts, use only 1¼″ antenna mast sections. Lengths over 10 feet should be guyed at least each 10 foot section.
11. If you are using plumbers-type waterpipe, use no more than a 10-foot length, because of excessive weight and guying difficulties.

CUTTING INTO A WALL

Running in-wall cable for connecting to wall-mounted outlets for TV, or cutting through the outside wall for lead-in feedthrough mentioned in previous chapters for TV and CB feeder cables poses some problems. The danger is hitting AC lines in the wall.

Local codes vary throughout the country as to how the AC lines in the walls are run. Some, like Chicago, require AC lines to be enclosed in rigid metal conduit. Others, like Albuquerque, permit AC lines in the walls to be a heavy-duty insulated cable but need to be in metal conduit piping. When cutting into a wall where there exists the latter type of AC wiring you run the risk of cutting into the AC lines.

Whether or not AC lines are in the wall at the spot you want to go

into it is determined by inspection. Observe if there is an AC outlet just below the spot where you want to work. If your home is a one-story home further inspection is by checking the points where the AC cables may enter the wall. If your home has a crawl space under it, the cables have probably been distributed to the various outlets by means of the crawl space. If you have an attic, that was probably the means of cable distribution. Inspecting these places will tell you where cables are located.

ROOF SAFETY

Working at roof heights presents some hazards that must be taken into consideration. This involves personal safety. If you have a heart condition, and/or are up in years, and especially if you have not had much experience at working on the roof, stay off. Let someone else do it for you. There is a certain excitement in working on a roof, and excitement that comes from doing something unfamiliar, and observing extra caution against falling off, that makes the heart beat faster, and calls for extra flow of adrenelin. Don't chance a stroke or heart attack if you have any sort of heart disease.

Rubber soled shoes are a must if you work on the roof, especially if it is a sloping roof. Avoid days of moderate to strong winds for obvious reasons, and avoid a rainy day. Water can be a lubricant to rubber soles, depending on the type of shingles. Be sure there is firm footing at all times.

LIGHTNING PROTECTION

Protection from the effects of lightning takes on two forms. One is to provide a continuous discharge of static electricity and therefore prevent damaging potentials from causing hazard to life and equipment. This is also thought to help prevent a direct strike of high-energy lightning. The second is to provide a high-conductance path to ground outside the buildings, or within the building structure in cases of high-rise buildings, to ensure the passage of a direct lightning strike without unnecessary damage to life and property. These two forms are mostly provided by the same treatment, that is, proper grounding of the antenna, mast, and tower system. The main difference in treatment is where the antenna cannot be grounded directly without defeating its function. Only certain kinds of antennas can be directly grounded.

Grounding is best accomplished as specified by the National Electrical Code and other codes. First, a large-size conductor without splices or other connections is connected between the base of the antenna mast or tower directly to an earth ground. This conductor

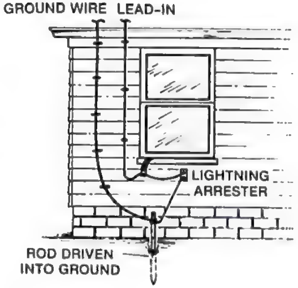
should be of no smaller size than No. 18 AWG copper or No. 16 AWG aluminum wire. Larger sizes are, of course, preferred. This ground wire should be routed as directly to ground as practical. It should not come near other conductors to which current must be prevented in case of a lightning strike. It does not have to be insulated, but should be kept clear of combustable materials. It must be protected from accidental physical abuse, especially at and near ground level. This might require the use of conduit (rigid or flexible) at or near ground level.

The earth-ground connection is probably the weakest link in all grounding systems. In order to obtain a high conductivity to earth, there must be a large surface area in contact with conductive soil. In areas of continuously wet or damp soil, this is easy to obtain, but in dry rocky ground areas it is almost impossible. Some general rules and ideas from past experience might be helpful here. First, wherever possible, the ground system installed and used for the AC power lines entering the building should be used. This also helps to keep potential differences from this AC source from showing up between two separate grounding systems. Usually though this only involves using the same ground rod(s) which are used for the grounding of the electrical system of the building. Connections to a ground rod should only be by an approved clamp made for this purpose. An extreme example of this shared system might be where a penthouse or high-rise ground system may have to be a secure connection to the grounded conduit system of the building.

Where you must install your own ground system, keep in mind that ground rods driven into dry ground under overhanging eves are virtually worthless. You must get at least 8 feet of ground rod into damp soil to be effective. This might require using two or more rods driven as deeply as the ground will allow and then bonding them together with heavy wire and approved ground clamps. Dry soil can be softened by allowing a trickle of water from a hose to soak the area for a day or more. You are allowed to use an angle of penetration up to 45° from vertical in order to get a lot of rod under ground before being bent or stopped by a layer of rock. In extreme cases, it may be best to dig a trench 2.5 feet or more in depth and then lay 8 feet of ground rod in the trench.

Some other effective ground systems include connections to cast-iron well casings, buried masses of galvanized iron (old water tank, pipe, etc.), and 8 square feet or more of buried copper sheet (flashing) or other parts. Back when all water systems were made with galvanized iron pipe, the outside faucet was popular; but now you must also include at least one ground rod along with a water pipe connection to ensure against a water system repair made with plastic pipe.

Figure 15-1. Installing a lightning arrester and ground wire.



The discharge of static electricity from an antenna which can not be grounded may take the form of an arrester. This is preferably mounted either at the base of the mast or tower where the feed line separates from it or just before entering the building. See Figure 15-1 for a typical arrangement. The arrester should provide both a high resistance discharge path and closely-spaced arc gap to ground for static charge. The device may be a simple resistor having a resistance 20 times the impedance of the cable or, as in the case of amateur and CB equipment, an RFC (radio frequency choke) having an impedance many times higher than the cable impedance of 50 ohms. Figure 15-2 shows an arrester for use on a TV 300-ohm twin lead. It has a strap for mounting to a grounded mast or tower as well as a ground screw for those uses at the point of entry to a building. Connections are made to both lead-in wires by insulation-piercing washers. Figure 15-3 shows an arrester made for use by F-type connectors as used with 75-ohm coaxial cable.

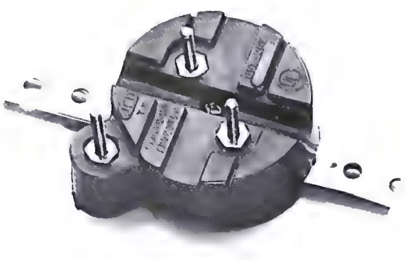


Figure 15-2. Lightning arrester used with twin-lead cable.

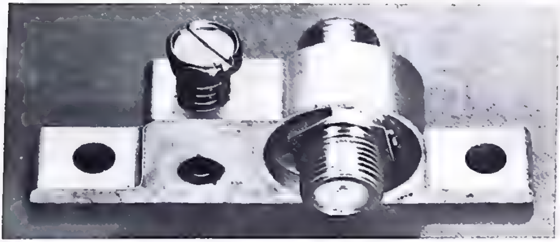


Figure 15-3. Lightning arrester used with coaxial cable.

The best protection against damage from a direct lightning strike is to remove the lead-in from the set and ground it to an outside ground wire, and unplug the set from the AC outlet. Both of these actions are required, as can be witnessed by many of us who have seen the effects of direct hits on sets which were turned off, but you would never know it by the extensive damage received as the lightning used the TV set to find its way to the building's AC wiring and eventually to ground.

SOIL EFFECTIVENESS

The effectiveness of any soil as a grounding medium depends on its electrical resistance. While the resistance can be measured, this is beyond the scope of this book. It is enough to say the lower the resistance the better, and this is a function of the type of soil. Clay type soil usually has a lot of moisture and is the best type of ground. Sandy soil, such as in the Southwest is the poorest. A loamy or organic (black) soil is somewhere in between.

The depth to which a ground rod is driven is important in this factor of resistance. A rod driven only 2 feet into the soil has three to four times the electrical resistance than one driven 10 feet down.

Grounding soil can be improved by treating the soil around the ground rod, but is generally not recommended because of the corrosive effects of the treatment chemicals and the need for periodic maintenance which tends to be neglected.

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